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FOREWORD

The papers which appear in this and the following number of the "JOURNAL OF THE DEPARTMENT OF AGRICULTURE OF PORTO RICO" have all been read at the meetings of the *"Association of Sugar Technologists of Porto Rico."* The papers which were presented at the first meeting of the Association which was held on June 17, 1922, at the Carnegie Library, San Juan, P. R., were published as Vol. I, No. 1 of the *"Memoirs of the Association of Sugar Technologists of Porto Rico."*

During the last year, the work and development of the Association has become so intimately connected with the Department of Agriculture and Labor of Porto Rico, and especially with one of its branches, the Insular Experiment Station, that it has seemed advantageous to publish its proceedings in the "JOURNAL OF THE DEPARTMENT OF AGRICULTURE", a periodical which has attained a wide reputation and circulation among the scientific world. Consequently, Nos. 2 and 3 of Vol. VIII of THE JOURNAL have been assigned to the publication of miscellaneous papers on sugar-cane culture and manufacture. No. 2 will contain a number of interesting papers which were read at the meetings held on January 5, 1923; June 17, 1923, and June 14, 1924, while No. 3 will be taken up by an article of our Cane Technologist, Mr. Arthur H. Rosenfeld, on the "Java P. O. J. Canes in Tucumán and Porto Rico".

A word about our Association. The necessity of this association was strongly felt by our trained men in the different fields of our sugar-cane industry. Thanks to the initiative of Prof. F. S. Earle and other enthusiastic men, a preliminary meeting was held in San Juan, early in April, 1922. The first regular session was held on June 17, 1922, and a large number of our prominent sugar men were present. Prof. F. S. Earle, was chosen first president, and the Association held its own with enthusiasm for a year or so. Unfortunately for us, the "old man" left his position in Central Aguirre, to accept a more lucrative one with the General Sugar Co. interests

in Cuba. Professor Earle's departure was a hard blow on us, but our spirit did not die out, and our last meeting, held on June 14, 1923, was a great success. The audience was honored with the presence of Prof. F. D. Kern, dean of the graduate school of the Pennsylvania State College, and Prof. H. H. Whetzel, of the Department of Plant Pathology, Cornell University. Both of these gentlemen delivered short addresses which were well received. Practically all the centrals of the Island were represented at the meeting.

It may be safely assured that our organization has already visualized the great possibilities which may develop in the future, in the way of lending a helping hand to our colleagues from Cuba and Santo Domingo, who according to late reports are very badly struck with the mosaic disease and the variety problems. Will our Association in the future extend its scope to the rest of the West Indies, or possibly to the rest of the sugar-producing countries of America?

CARLOS E. CHARDÓN,
President.

SUGAR-CANE CULTIVATION

By F. S. EARLE, Agronomist, Central Aguirre

Sugar-cane agriculture in the West Indies is fifty years behind the manufacturing side of the industry. It is hard to understand why this should be so, but no one conversant with the facts will dispute it. Nothing is more urgently needed than to bring the work in our cane fields into accord with the farm practices long recognized as indispensable in the growing of other similar crops. Sugar cane, in order to produce a maximum yield, requires a heavier rainfall or a more abundant supply of irrigation water than is needed for most crops, and it needs it, too, for a longer period. Now the only known way to supplant rainfall and to conserve soil moisture is by giving frequent surface tillage to form and preserve a dust mulch. This has been thoroughly understood for many years and it is the regular practice with all similar crops. Why not with sugar cane, which needs it even more? In the corn belt no one thinks of planting corn without giving it constant cultivation. Even as drouth-resistant a plant as cotton is cultivated most carefully. In Louisiana cane is cultivated like a corn field. It is only here in the West Indies, on the hardest and most compact soils and with the most capricious of rainfalls, that we expect cane to grow and yield full crops year after year without this fundamentally necessary assistance. Our present methods have come down to us from the times when cane was planted on new lands—freshly cut-over timber lands. No special cultivation was needed then, nor is it needed today on such new lands. The humus which they contain so abundantly holds moisture and the decaying rootlets leave the ground porous and well aerated. All this changes with age as the soils become hard and compact, when this porousness and permeability to air, so necessary for plant growth, has to be restored by tillage. The roots of sugar cane are very susceptible to lack of air. When the soil becomes encrusted they quickly suffer and are apt to be attacked by the fungi causing "root disease", a condition causing more losses to cane on old lands than all of the other cane troubles combined. It is "root disease" that has coused so many of the old standard varieties to fail as the land becomes more hard and compact through continued cropping and the loss of vegetable matter. In one country

after another first Otaheite and the Rayada and Cristalina have gone down and been abandoned on account of "root diseases." This trouble has caused the loss of untold thousands of dollars in all parts of the sugar-cane growing world, and yet it is easily controlled. Three things are required, and of these each is as important as the other: first, proper drainage; second, abundant fertilizing, and third, frequent tillage. Used with good judgment and common sense these three things will prevent nineteen-twentieths; yes, ninety-nine hundred of the cases of root disease, and at the same time will so increase yields that they will prove a decided economy and not an expense.

More tillage, then, is a necessity if we are to secure full yields of cane on old lands, first, to conserve moisture and, second, to aerate the soil so that the roots may be supplied with oxygen, for they are living things and, like everything else which has life, they take in oxygen and give off carbonic-acid gas. When the soil is hard and encrusted this necessary exchange of gases is impeded and the vitality of the plant suffers. Anything which lowers the vitality of the cane plant permits the attacks of the root-killing fungi. Again, the presence of oxygen in the soil is necessary for the growth of those soil bacteria that are instrumental in transforming the crude plant food contained in the soil into nitrates and other forms in which it is available for growth. In badly aerated soils another set of organisms develop which destroy these nitrates and thus rob the soil of its fertility. Some recent investigators have gone so far as to claim that this effect of tillage in rendering the plant food in the soil more available is the real reason for its beneficial effect during period of drouth. The soil solution is made richer in plant food and so less of it is required to keep the plant in active growth. Be this as it may, the outstanding fact remains that frequent shallow tillage during dry weather aids remarkably in keeping crops in active, vigorous growth. Why, then, do not cane planters, like other farmers, take advantage of this long-known and well-established fact? The only answer is that they are still blindly following the customs of their fathers: customs sufficiently well adapted to the fresh new lands of those times, but not adapted to the compacted and partially exhausted lands of today.

By tillage is meant any stirring of the surface soil between growing plants with implements. This may, of course, be done by hand with the hoe or rake. The surface scraping usually done with

the hoe in Porto Rico can hardly be called tillage since it does not brake the surface crust. Usually it is more cheaply and effectively done by implements drawn by animal power. Mules and horses are better adapted to this work than oxen and usually their work is much cheaper. Tillage by tractors is surely coming in the near future, but so far it has hardly passed the experimental stage. The kind of implement to use for cultivation will depend on the system of planting adopted and to some extent on the nature and condition of the soil. The more generally useful tools are the 5-shovel cultivator, the 13-tooth harrow cultivator, the double shovel, the single shovel or Georgia stock with its various attachments and the small 7-inch turning plow. First one and then another of these implements should be used according to the condition of the land and the amount of weed growth. The small reversible disc harrow with only six discs is often very useful, especially when the land was crudely prepared. The straddle-row riding cultivators had best not be attempted until after our labor becomes accustomed to handling these simple instruments. When properly handled these implements, working as they do on both sides of the row at once, are great savers of time.

There are three principal systems of cane planting in use in Porto Rico. Each will require special methods of cultivation in order to secure best results. The irrigated lands are mostly planted on the Hawaiian system, first successfully introduced by the late Patrick MacLain when he was Administrator of Central Aguirre. In this method the cane is planted at the bottom of deep furrows which are laid out as nearly as possible on the level grade lines. These planting furrows are crossed at intervals of thirty to forty feet by light furrows for bringing in the water. This secures a more uniform distribution of water than is possible with the old system of running the rows with the grade and allowing the water to follow them for considerable distances. Having to maintain the banks between the rows to confine the water makes tillage more difficult than where level culture is possible. This has been made an excuse for doing little or no cultivation on the irrigated lands of the southern coast where the tendency has been to depend on irrigation water alone to make the crop. This is a serious mistake, especially in the ratoon fields. Much better results will follow if each irrigation is followed within a few days by a cultivation to break the crust and restore a dust mulch. From 20 per cent to 25

per cent less water will be required and better crops will be secured. For this cultivation it is best to alternate, using first the harrow-cultivator held at an incline first on one side of the bank and then the other. This implement tends to pull down the banks and after using it a few times the 5-tooth cultivator should be substituted for it, putting on the broad hilling-up wings that come with it and taking off the three forward shovels. The wings should be set to turn the dust toward the middle and the width should be adjusted to fit the bank. This will restore the central ridge to hold in the irrigation water. The single shovel or Georgia stock with a 16-inch "heel sweep" may now be used between this central ridge or bank and the cane to clean out and open up the water furrow. By the alternate use of these three cheap and simple implements irrigated cane may be cultivated easily and effectively. Simply follow every irrigation or rain by a cultivation. That is an easy rule to remember.

Dry uplands that are unirrigated and where no extensive drainage is required are best planted on what may be called the Cuban system, since it is employed so widely in that island. The cane is planted in deep furrows as for irrigation but, it is usual to run through with enough slope to carry off an excess of rainfall. These furrows are gradually filled in by the cultivation and when the cane is laid by the ground should be nearly level. This is the simplest kind of cane cultivation. The seed should be placed in a single continuous line in the bottom of the furrow—not in a double line nor in wide "holes" with spaces between, for this leaves space that requires hoe work. Any of the above-mentioned implements may be used with this system of planting. If done frequently enough to destroy the grass and weeds as they are sprouting, the 13-tooth harrow-cultivator will be the only implement needed, and, if care is taken each time to run close to the cane, almost no hoe work will be required. If continued rains do not permit cultivation and the cane gets grassy it will be necessary to use either the double shovel or the small turning plow, but these implements should be followed closely by the harrow-cultivator. It will pay to run the cultivators as often as every ten days, or in some cases even oftener. Always cultivate as soon as possible after a heavy rain. Remember you are not cultivating primarily to kill weeds but to aerate the soil. Weed killing is a useful secondary benefit.

All wet lands that require drainage should be planted on the

Porto Rican *gran banco* system. Many Porto Rican cane lands are of this nature and this system has been developed here locally to meet these conditions to which it is admirably adapted. In Louisiana cane is also planted on low, wet lands. There they meet this condition by planting on top of sharp single-row ridges. The land is prepared much as for planting according to the Cuban system, but the cane is planted on top of the bank and not in the furrow, which is kept open for drainage. This Louisiana system would not be well adapted to Porto Rico since here cane even on wet lands sometimes suffers from drouth and these narrow ridges would dry out unduly. The Porto Rican *gran banco*, wide enough for two cane rows, do not dry out so quickly. When laborously made by hand with the shovel, which is still the usual practice, they are very expensive. In most cases there is no need at all for this and it is a custom which should be immediately abandoned. No conceivable "protection duty" will serve to make cane growing permanently profitable if such expensive practices are followed. Most of these wet lands are dry enough at some season of the year to admit of preparation with the plow. They should be prepared at such times. Deep plowing is not required but the surface should be well pulverized by several harrowings. Then lay off the banks with a big turning plow giving two cuts in the same furrow, and removing as deep as possible. Clean the furrow either with the big double mould board (*bombo*) or with the Martin grader or with both, and the banks are made. Open a light furrow on either side of the bank with a 7-inch turning plow as a guide in planting and plant in a single line (*chorro*). Do not destroy the bank by making a deep furrow for planting and do not plant in holes for this makes your rows so wide that there is no space for cultivation. Cultivate on top of the bank with the harrow cultivator much as in the Cuban system. Before the ditches get set with grass clean these with a pass of a medium-sized double-mould-board plow. The one used in Cuba for opening planting furrows and there called a *limpiador* will be about right. This will keep the ditches clean much cheaper than it can be done by hand. On very wet lands where there is constant standing water in the ditches the above directions cannot always be carried out. In such cases it is usually better to make wide 20-foot banks with deep permanent ditches between them. These will likely have to be made by hand and they should be carefully run in the direction to give best drainage. After the ditches are opened the land will soon dry enough so that the

top of the bank can be prepared with a small 8- or 10-inch plow. There will be room for four rows and level cultivation can be given. This plan is working well in actual practice.

Whatever plan of planting is followed it is of great importance to put at least 400 pounds of fertilizer per acre in the planting furrow before planting. A second application can be given at the side of the cane row when it will be covered by the cultivation after the cane is two to three feet high. Subsequent applications, however, cannot take the place of this first one in the bottom of the planting furrow. This not only places it where it will be immediately available for the young roots as they form, thus insuring a vigorous early growth, but, by its deep application it induces a deep rooting habit that better enables the young plants to resist drouth. Applications made after planting are necessarily placed above the roots and the tendency is to induce a shallow root growth. The importance of this matter cannot be too strongly insisted upon, though it seems to be little understood in Porto Rico.

It is, however, in the ratoons that better cultivation is most urgently needed. With plant cane the ground has been thoroughly loosened and mellowed in the preparation for planting so that in many cases fairly satisfactory growth is secured with a minimum of cultivation. In the ratoons the soil has been compacted by the trampling of men and teams in getting off the crop and it is of urgent importance to restore it as soon as possible to a condition of mellowness and good tilth. The practice should be much the same with either of the systems of planting. First line the trash in alternate middles and let it lie there as a mulch throughout the season. This reduces the area to be cultivated by one half. The expense of transferring the trash and working the second middle may usually be avoided since the heavy mulch tends to soften and mellow the soil beneath it. Each row will therefore be mulched on one side and cultivated on the other, thus getting the benefit of both. In the case of *gran banco* plantings, however, it will be necessary to at first line the trash in the ditches and later transfer it to the top of the bank after that has been thoroughly pulverized. As soon as possible after lining the trash and before much new root growth has started, "bar off" each side of the cleaned middle with a 10-inch ploy running as close to the cane as possible and throwing the dirt toward the middle. In the furrow thus formed put in the first application of fertilizer. On most soils it will be best

to mix this in the soil by passing a subsoil flow to stir and open up the soil still more deeply. This should be immediately followed by the harrow-cultivator to pulverize the furrow sluices that have been thrown out and to partially fill the furrows and cover the fertilizer. After this the work will be about the same as in plant cane. An implement of one kind or the other should be passed every ten days or two weeks until the cane closes. The main point is to see that it is passed quickly enough after each heavy rain to prevent baking and the forming of a heavy crust that will impede aeration.

The expense of the method of cultivation here outlined will be but little if any greater than at present since it will save the larger part of the hoe work. It will largely increase yields and will make possible the taking of many more ratoon crops than at present. Above all, nine-tenths of the present losses from root rot will be avoided. Try it out carefully, gentlemen, and see the results for yourselves.

CANE VARIETIES RESISTANT TO SALT LANDS

By F. S. EARLE, Agronomist, Central Aguirre

On both coasts of Porto Rico there are various tracts of land too salty to permit the growth of the ordinary sugar-cane varieties. In some cases heavy losses have been made in attempting to plant these lands. These salty tracts are more frequent on the dry, south coast, and here unfortunaly some tracts, formerly productive, have become salty owing to carelessly allowing irrigation water to stand and evaporate in low places. Some work is being undertaken to see if such lands can be reclaimed by proper banking and ditching. In this connection it becomes important to know which cane varieties have most resistance to salt and consequently which it will be safest to first plant on these lands. It had already been observed that Uba and Sealey's seedling showed rather more resistance than Crystalina, while Yellow Caledonia and Cavengirie were if anything more susceptible.

To test this matter farther, on September 20 ninety-three varieties were planted in small plots of about 20 seeds each on land so salty that a planting of Crystalina made last March had completely failed. The differences in the behavior of these different kinds is very interesting, although it is still too early to draw final conclusions. The usual effect of salt is to retard germination even where it does not prevent it. As was to be expected the germination was slow and uneven. After three weeks only 4 kinds showed as many as 20 shoots, 23 showed between 10 and 19 shoots, 27 kinds had 5 to 9 shoots, 34 kinds 1 to 4 shoots and 4 showed no germination. Some of those that germinated most promptly and uniformly soon began to turn yellow and fail. There are others, however, that continue to show good color and vigor. It is quite noticeable that a much larger percentage of these are found among the Demerara seedlings than among those from either Barbados or Porto Rico. There are 8 Demerara kinds in the experiment and all of them except D-433 are so far quite satisfactory. Of the 17 Barbados kinds only two or three are equally good, while of the 41 Porto Rican kinds only two or three are good while many are failing completely. This result was perhaps to be expected since the Demerara kinds were bred and selected on low, maritime lands protected from the sea by dikes where

the soil must of necessity be still somewhat salty. Naturally only those that can resist these conditions have been selected. The Barbados and Porto Rican kinds, on the contrary, have been bred on uplands and were selected with no reference to salt resistance.

Among those making the best showing at the present time may be mentioned Bamboo Blanca, Penang, Rosa Morada and Uba, among the older named kinds; and B–208, B–6536 and BH–10(12) among the Barbados kinds. Among the Demerara kinds D–117, D–448, D–504 and D–625 are best showing full stands and good vigor. D–109, D–350 and D–1135, have equally good shoots but the stand is broken. Among the Porto Rican seedlings PR–333, PR–460, PR–16(874), PR–18(153), and PR–18(171) still give some promise, but PR–202, PR–207, PR–260, PR–271, PR–328, PR–417 and PR–449 are already complete failures.

The final result of this experiment will be of great interest and considerable practical importance.

IMPLEMENT TILLAGE FOR IRRIGATION

By R. L. PAGE, Manager of Cultivation, South Porto Rico Sugar Company

The task of introducing implement tillage into a country where this method of cultivation has never been practiced, is one beset with many difficulties. In the first place, I don't believe there is a business under the sun, where inefficient work will show up to worse advantage than poor work in cultivation with implements. And the economical results of poor cultivation are equally disastrous.

Therefore, it is easy to comprehend what one has to contend with when you try to introduce this work into a country where there are no teamsters, and where none of the laborers have the slightest conception of the principle of the implement, and the *mayordomos* are very slow indeed in learning to use judgment in putting different instruments in the different fields as conditions change.

Another idea which we have not been able to impress on our *mayordomos*, is that implements should be confined to such territory as they can attend to properly, and leave the rest of the work to be attended to by hand.

Another condition that was met with here. These fields never have been cultivated by animal power, so were not layed out with the idea of accommodating this kind of work.

Also each country has its peculiar conditions that required certain implements. Some of them may be found on the market, and others have to be improvised. These are a few of the things that have to be contended with while introducing a proposition of this kind. However, they are minor details, all of which may be overcome in time.

The chief questions that have to be determined are whether or not you are able to cultivate a piece of land cheaper by this method, whether you can produce more tons per acre, and whether or not you are able to make as good use of a limited water supply for irrigation.

In discussing tillage with irrigation there are two distinct propositions to consider:

One, where you have an abundance of cheap water, where the only object in cultivation is to maintain a good soil condition for the cane, and the other, where you have a very limited supply of

expensive water and where the only object is to make a gallon of water reach over as much territory as possible, never pretending to give the plant all the water it wants, merely holding it up until it rains.

The former is quite simple, and there really is not much room for discussion. I have had occasion to introduce cultivation into a proposition of this kind and in many instances obtained an increase of 100 per cent in yield and a material reduction in cost.

However, with the latter, where we have a great scarcity of water and the water is very expensive, we meet with greater difficulty, and we have to proceed with more care and judgment than where water is plentiful and cheap.

As the condition of scarcity of water obtains more generally in the better cane districts in Porto Rico, I will discuss the subject under these conditions.

The primary principles of conservation of moisture in dry farming are well known to most every one, and these are the principles which have to be applied to cultivation with irrigation under these conditions, where conservation of moisture is of primary importance.

On undulating lands and in districts frequented by drought, there is no question but that the deep-furrow system is the most desirable. First, from the view point of controlling the irrigation water; second, from the fact that moisture is conserved longer in a deep furrow than in a shallow furrow, or on level land, providing proper mulch is maintained.

In carrying on intensive cultivation with implements, in connection with the deep-furrow system, the problem which presents itself is the one of conserving the banks for the purpose of controlling the irrigation and at the same time keeping soil in good condition without filling up the furrow too much.

In making a study of this phase of the problem, I have come to the conclusion, that in loose land where it may be desirable to work two animals abreast, the least practical width that banks can be made is 6 feet from centre of furrows. Anything narrower than this, where furrows are made with a large *bombo* (lister) with bulls or steam plows, lister or furrow machine, it is not practical to get onto the banks with an animal-drawn implement, as they are thrown up so high and steep that it is hard walking for the animals, and the implement will roll entirely too much dirt down into the furrow.

A 6 feet bank allows a furrow of sufficient depth and at the

same time a bank wide enough for animals to walk on without filling the furrow with dirt and clods. In this connection would state that where a good bank is made, as with a steam plow, it is not practical to go in with cultivators, until the banks have had time to settle, or have been worked down a little either with hoes or by rains. This lessens the danger of rolling clods down on the young shoots and at the same time gives the cane time to get up where it is not so easily disturbed by rolling dirt and clods.

There is no question, but what the continuous passing of implements works the banks down to a considerable extent, but this also takes place nearly to the same extent by the action of the rains and continuous passing of the hoe. And I find it is possible to lay the cane by with practically as good a bank by the use of animal cultivation as by use of hand implements, with the advantage that the cane is layed by with soil in a good state of tilth instead of in a hard baked conditions as when no implements are used.

In districts where (for lack of land) we are forced to put our fields back in cane as soon as the crop is cut, we have considerable difficulty getting rid of the old cane roots; while in the *gran cultura* planting the roots have pretty well disappeared through decay and repeated plowings.

In fields where we are obliged to chop up the stumps in search of the white grub and weevil root-borer, this trouble is done away with; and in fields not treated in this manner, where the old stumps are large and bothersome, we send men in with grub hoes and split up the larger stumps which interfere with the implements.

IMPLEMENTS

After having made a study of this subject for the past four years I have decided on the following implements, which we are now using under different conditions as requirements demand.

I have devised a banking machine, and a disc cultivator with eight discs. In addition to these I use a diverse or spring-tooth cultivator, an ordinary double-shovel cultivator, and small plows.

For conservation of moisture and destruction of small weeds just as they are germinating, I use the spring-tooth cultivator, with levers set so that teeth slant back toward the center of the bank; this has a tendency to draw the mould away from the cane, together with any loose trash and deposite it in the centre of the bank. This is drawn by one animal, and two passes are made; one down the

right side of the bank and back on the left side. We are doing this work now at an expense of 15 cents per acre.

For the destruction of small weeds and building up the bank which may have become flattened out from any cause or other we use the banking machine which is composed of two pieces of sheet iron five feet long set on a slant, with the front ends set apart, the width of the bank and the rear end set just far enough apart to allow the mould to roll out onto the centre of the bank. This is drawn by two good mules, and as this requires only one pass, we pay 8 cents an acre for this work. We find that by passing this implement after cultivation with other implements, we are always able to keep the banks in a satisfactory condition and never lose control of our irrigation water.

After the banker we quite often run the disc cultivator, which leaves a mulch on the sides of the bank next to the cane. When the bank becomes slightly packed as a result of passing these implements, we go in after irrigation with a double-shovel cultivator and make three or four passes as the case may require, and if the bank has become very hard we go in with a small plow and break it up thoroughly, then follow up again with the banker and other implements as the case may require.

It is always desirable, after passing either the small plows or double-shovel cultivator, to pass the diverse or spring-tooth cultivator at once. By this I mean the spring tooth should be in the field at the same time as, and only two or three furrows behind, the small plow or double showel. This will assist materially in conservation of moisture as well as improving condition of soil.

In addition to this system of cultivation, we have introduced in the Guánica dictriet, for the conservation of moisture, and to prevent germination of weeds, the practice, after each of the first three or four irrigations of mulching, or pulverizing the irrigated surface in the bottom of the forrow, both before and after germination, with a tool known in the United States as a potatoe hook–which is a heavy rake of four or five prongs. This operation to be of any material benefit must be done soon after irrigation.

In my opinion, by this treatment of the soil we get considerably more benefit out of our irrigation water, which in the Guánica group constitutes our chief expense.

The foregoing is with reference to our district where (1) we rely principally on our pumps for moisture, (2) where soil is prin-

cipally loose loam and readily adapted to cultivation and very productive with sufficient moisture, (3) where due to pests we do not make a practice of ratooning.

In our other districts where we depend almost entirely on rain, conditions are quite different. The soil for the most part is of a stiff clayey nature, becomes exceedingly hard immediately after rain or irrigation if not properly worked, and has always been considered rather poor in regard to productiveness. And I believe it is on these poor soils where we are deriving greatest benefits from cultivation. A large portion of these lands are farmed in *grand banks*, or in *tableta* of from three to four rows in a *tableta*. Here a greater portion of the year, conservation of moisture is *not* the chief object; but the desired result is to maintain a good soil condition and keep down the weeds, thereby reducing the expense.

However, in accomplishing this we find that where we are able to obtain a good soil condition or mulch before drought, that the cane on these fields comes through the dry weather in good shape and makes some growth instead of drying up and dying back, as in fields not cultivated.

In these fields, where we have to pay more attention to drainage than to irrigation, we make no effort to maintain the bank between the row, and sometimes even bank the dirt on the cane row.

Here also we are never bothered with old cane roots, as land always lies idle a few months giving roots time to rot.

In these districts we ratoon a great deal and start these off by lining trash on every other bank and plow the clean bann with as large a plow as is practical, then trasfer the trash to the plowed bank and plow the other one. In some cases where, due to floods, we are obliged to burn the trash to prevent same being piled on young cane, we go in with a 9-inch plow and three yoke of bulls or three teams of mules and offbar as deeply as possible up close to the cane row. Then we apply fertilizer and either plow this dirt back or work it back with the cultivator.

I am very much in favor of offbarring and believe it should be practiced wherever possible.

In some of these poorer districts we have, through eradication of diseases, introduction of new varieties and cultivation, been able to raise our average yield in tons per acre in the past four years, from 11 and a fraction tons up to an average of 24.6 tons for the crop just finished. Just how much of this increase is to be credited

to cultivation cannot be stated, but there is no question but that cultivation is entitled to a part of it.

Conditions with reference to drought, disease and pests have been so unusual during the past four years, that it has not been possible to compile any positive data regarding the actual advantage to be derived from implement cultivation; and as conditions on different parts of the Island vary so much, any one introducing cultivation with implements has to figure out methods which will apply to his particular conditions.

And while in many instances it may not be practical to introduce a system of intensive cultivation with implements, I am firmly of the belief that in nearly every instance, some implement can be profitably introduced.

WHITE GRUBS, *LACHNOSTERNA* sp., AND LARVAE OF THE WEEVIL ROOT-BORER, *DIAPREPES SPENGLERI* L., ATTACKING SUGAR CANE IN THE GUANICA DISTRICT OF PORTO RICO, AND METHODS PRACTISED FOR CONTROLLING THEM.

By E. H. Barrow,
Assistant Manager of Cultivation, South Porto Rico Sugar Company

Since the Mosaic disease has been reduced during the last two years from between eighty and ninety per cent to one-tenth of one per cent, the most serious menace to sugar-cane growing in the Guánica district is the damage caused by the attacks of white grubs and larvae of the weevil root-borer.

White grubs, *Lachnosterna* sp., have been causing considerable loss in the Guánica district for several years past. These grubs are the larvae of what are known as "May beetles" or brown-back beetles, and eat the roots of the sugar cane and other plants.

These white grubs have been recognized as a serious pest of sugar cane in this district for a number of years and considerable work has been done to try and exterminate them or at least to reduce their number. Reducing their numbers is the only thing that can be hoped for at present and so the work will have to be continued persistently year after year to accomplish it.

The work which has been carried out principally and which is the only possible means as yet known to keep them in check is the collection of grubs and beetles. After the canes are reaped and the trash burned off of the field, the cane stools are plowed out, gangs of men are put into the field to cut the stools in pieces with pick-hoes and collect all the grubs that are found. A careful record is kept of the number of grubs collected and the expenses thereon. The following figures for the past five years may, therefore, be of interest:

Year	No. of grubs	Expenses	Cost per 100
1919	3,055,317	$4,095.48	13.4 cents.
1920	1,745,125	6,003.15	34.4 "
1921	282,452	948.75	34.8 "
1922	926,452	1,196.10	12.9 "
1923 (1)	586,908	835.03	14.2 "

[1] Including 209,311 larvæ of the weevil root-borer.

In the years 1920 and 1921 it will be remembered that the cost of labor was exceedingly high, and for this reason the cost of collection in these two years was over twenty cents per hundred more than that of the other three years, when the cost ranged from 12.9 to 14.2 cents per hundred.

The collection of beetles is carried out every night when they are in flight, generally from April to December in each year. The beetles are found on the cane leaves and on the leaves of most weeds and bushes, and certain trees. A careful record is also kept of these collections and the following are the numbers collected during the past six years:

Year	No. beetles	Expenses	Cost per 100
1918	1,529,225	$720.49	4.7 cents.
1919	1,007,835	524.17	5.2 "
1920	No record		
1921 [1]	248,282	195.55	7.9 "
1922	2,129,985	1,086.88	5.1 "
1923 [2]	1,543,841	621.67	4.0 "

[1] To July 7. [2] To June 7.

For the year 1920 no record was found as to the number of beetles, and so I cannot say if beetles were collected or not that year. In the following year, 1921, collection was only made to July 7, when all work was suspended on the collection owing to the sugar situation that prevailed at that time. This no doubt caused the number of grubs and beetles collected in 1922 to be greater than in the previous year. On referring to the tables it will be noticed that the numbers collected were decreasing up to the date when collection was stopped and began to decrease when collections were again made.

It has been noticed that the beetles emerge in large numbers after rains, and this is perhaps one of the reasons why so many have already been collected this year, as there have been a few showers in this district during the past few months.

From a scientific point of view all grubs and beetles that are to be found should be collected and destroyed, but this is not possible on the practical side, as the cost per hundred has to be taken into consideration. The gangs are therefore increased or decreased in proportion to the numbers that are being found, and in this manner collections are made at the lowest possible figure. In some instances the work is paid for by the number collected, but generally it is done by day labor.

From October 1920, the date that I arrived in Porto Rico, I was constantly on the lookout, and actually made several days' search on different occasions for *Tiphia* wasps, a species of which I knew was keeping white grubs in complete control in a certain disrict in Barbados. It was not, however, until August 1921, nearly a year after my arrival, that I found any of these wasps. Specimens of these were collected and shown to Mr. George N. Wolcott, the Entomologist of the Insular Experiment Station, on his subsequent visit to Santa Rita. Mr. Wolcott was very glad to know that I had discovered these wasps, as several years before he had done considerable work in introducing them into the Island, and, up to that date, none of them had been seen. A paper by Mr. Wolcott on this subject has been recently published in the JOURNAL OF THE DEPARTMENT OF AGRICULTURE AND LABOR OF PORTO RICO, Vol. VI, No. 1. At the suggestion of Mr. Wolcott, specimens were sent to Mr. S. A. Rohwer of the United States National Museum, for identification, who wrote me on October 21, saying, "The three wasps you sent with your letter dated October 7th reached me in good condition. I have examined them and believe they represent a new species of the genus *Tiphia*. This new species is very similar in many ways to some of the species which Mr. Wolcott introduced into Porto Rico several years ago, but I believe it is specially distinct." It cannot, however, be stated that these wasps are parasitising the white grubs, as up to the time of writing no grub has been found parasitised by them.

Various preparations, etc., have been experimented with to try and discover something that could be used against these pests, but nothing has yet been found that would be really useful in combating them.

To give some idea of the loss caused by these pests, it may be of interest to mention an instance. This year canes were reaped from a field, ten acres of which were severely attacked by white grubs. These ten acres yielded only eleven tons of cane per acre while the remaining fifty-seven acres in the field yielded thirty tons of cane per acre, or in other words, nineteen tons of cane per acre more than the attacked canes.

THE WEEVIL ROOT-BORER

The weevil root-borer of the sugar, *Diaprepes spengleri* L. is the larva of a small whitish beetle with black stripes. These beetles are

locally known as *vaquitas*. In comparison with the white grubs I consider that they are a more serious pest, as they bore into the root stock of the cane and thus do more damage and make collection more difficult and expensive. It is also claimed that one borer is capable of killing an entire stool of canes.

They were known to exist in this district for a number of years but no record has been found showing that they were doing any serious damage to the cane. Even the first crop, 1920–21, that I was in the district no serious damage was noticed as caused by them.

In February 1921, however, serious damage was observed as having been done by larvae of the weevil root-borer to canes on a certain field on one of our *haciendas*. The canes on this field of thirty acres were killed and had to be reaped when they were yet quite immature. Needless to say the tonnage was very low and the juice from these canes very poor, only averaging 12.8 per cent sucrose and 70.8 per cent purity. On this field the following work was carried out, which proved to be very effective:

As soon as the canes were reaped, the trash on a portion of the field was burned off and the cane stools ploughed out very carefullly. A gang of men was put to cut the stoools to pieces with pick-hoes, shake the mould off, and place them in small heaps. A cart was then sent along to collect the stools thus prepared and take them away to be burned. The best method of burning these stools was found to be in the following manner: A small heap of trash was made, on which a few pieces of the stools were placed. The trash was then lighted and when a brisk fire was burning more trash and stools were placed alternately in the fire. The main idea is to keep a brisk fire burning and not to place too many stools in it at one time, as the only hope of killing larvae is by having sufficient heat to penetrate the cane to where they have tunneled.

If it is intended to do this work it should be done as soon as possible after the canes have been reaped, for if too long a time elapses, the borers are liable to leave the stools and enter the soil, where it is difficult to find them.

The field was then ploughed and kept free from weeds by ploughing or harrowing each time any weeds started to grow. The idea of keeping all vegetation from the field, was to prevent any beetles that emerged from having any place to hide.

To facilitate the collection of the beetles, pigeon-pea bushes *Cajanus cajan*, are planted around all the fields in this district, as

I discovered in Barbados that great numbers of both of these beetles congregated on them as well as on those of cassava, *Manihot utilissima*. Collections of these weevils are made by day and was first started in March last year. The total collected to the end of December last year were 11,698,000 at a cost not quite four cents per hundred. The largest collection made was the two weeks ending October 26, when over three million were collected. To date this year 4,000,000 have already been collected.

The weevils deposit their eggs on the leaves of the sugar cane and other plants, in small batches and then stick a piece of the same or another leaf over them. The gangs collecting the weevils are instructed to collect these egg-batches also, but, as they are very difficult to find, very few are collected.

Towards the end of February a few acres in a field of *gran cultura* canes, only five months old, were noticed to be drying off. On examination it was found that this was due to the attacks of the weevil root borer. Immediately all of the stools that were so attacked were dug out, the grubs collected and the spaces replanted. The total number of stools dug were 14,572, or just as many as would be in nearly three acres. From these stools 39,674 larvae of the weevil root-borer and 3,003 white grubs were collected. As may be imagined, this part of the field now has a very ragged appearance.

In this piece three plots were marked off and paradichlorobenzine was applied to two of them at the rate of 200 and 400 pounds per acre respectively, and the other plot was left as a check. The plots were examined regularly but in no instance was a dead borer or grub found. The plots to which the applications were made showed no improvement over the check. Further experiments will be carried out with this chemical to see if it can be used with effect.

MOSAIC INVESTIGATION AT CENTRAL CAMBALACHE

PRELIMINARY REPORT

By CARLOS E. CHARDÓN, Commissioner of Agriculture and Labor

The first records of the sugar-cane mosaic in Porto Rico date back to 1915, when Stevenson reported its appearance in the Arecibo valley. It was probably present there a few years because already at that time the infection of the fields was well advanced. In a few years, the epidemic spread, and in 1919 it practically covered all the Island except the isolated valley of Yabucoa. At the present date a great advance has been made in the way of controlling the malady, and while in certain places the "roguing" method has been effective in checking the disease, in others, the displacement of the old "cristalina" and "rayada" types of cane by the immune Uba and the resistant P. O. J. seedlings have been the total salvation of the sugar growers. If conditions favoring the successful exploitation of these immune and resistant varieties would exist all over the Island, then the whole mosaic problem would be satisfactorily solved, but unfortunately, there are important sugar regions in the Island where the Uba cane will not yield a dependable amount of sugar. I am referring to the alluvial soils of the north coast, the valleys of Arecibo, Manatí and la Plata Rivers. These valleys comprise thousands of acres of excellent soil and include the best of the fields of centrals Cambalache, Caños, Plazuela, Monserrate, San Vicente, Carmen and Toa Sugar Company.

Mosaic is more or less widespread in the fields of these seven centrals and it certainly constitutes an important factor in the production of sugar. I know of one of these centrals whose production dropped from 183.00 bags to 87,000 bags in one year, chiefly due to the ravages of the mosaic as it has been cofessed to me by its president. On the supposition that only 50 per cent of that loss is due to the mosaic, and with sugar at $4 a quintal, the loss to that factory alone will amount to $480,000.

It has been stated before that the immune Uba will not yield on these soils a dependable amount of sugar, although it is true that there have been exceptions to the rule; however, in the great majority of

cases, the sugar yield has been disastrous. Dealing with rich, alluvial soils like these, where heavy rains are frequent, it is very doubful whether the Uba will ever be a promising variety here, and consequently the possibility of controlling the mosaic by the use of the immune Uba, is for the present discarded. The P. O. J. seedlings have been tried in the upper portions of the Arecibo valley, especially in central Los Caños. Our sugar technologist, Mr. A. Rosenfeld, has already read a very interesting paper on the behavior of these varieties under Porto Rican conditions. Good results have been accomplished with P. O. J. 36 and P. O. J. 213, and the early maturing P. O. J. 234 is very promising. However, P. O. J. 105, known here as "Egyptian" and which is the most wide-spread of them all, has proven to be rather low in sucrose and a poor ratooner. In fact, the propagation of "Egyptian" cane is not recommended any longer. The other varieties of Java would had been propagated more, had it not been for the spectacular appearance in the Island of the B. H. 10–12 and the S. C. 12/4. The luxuriant vegetation and enormous sugar yield of these two varieties are surprising and they promise to cover a wide area of the Island in the next few years.

The sugar yield of these two varieties, B. H. 10–12 and S. C. 12/4, at Central Cambalache surpasses all previous records and they have been propagated extensively in the Arecibo valley, covering at the present time about 700 acres. In the next two years they will cover practically all the alluvial soils in the Cambalache field. Mosaic, however, has always been prevalent in the Arecibo region and since "rouging" has never been practiced here, the disease is widespread in these new fields of B. H. 10–12 and S. C. 12/4, sometimes passing the 80 per cent infection mark. It will be clearly seen that the situation requires deep consideration. It is true that second rattoons of these two varieties have not yet shown any signs of shrinking internodes or canker states. Thus far their behavior has been very satisfactory and somewhat approaching the conditions of the P. O. J. seedlings, which are 100 per cent infected here in Porto Rico, but which do not seem to be affected by the disease. What will be the final outcome of this extensive propagation of infected B. H. 10–12 and S. C. 12/4 at Central Cambalache, I am not able to forsee, but at any rate, it is an interesting experiment carried on an enormous scale which promises to be rich in valuable infor-

mation for the sugar men of the world, especially Cuba. If results show that these two varieties are resistant to the disease (somewhat aproaching the P. O. J. seedlings) it will be a great step in advance in the control of mosaic in the Island. If, on the contrary, these varieties fail in the future, then it will be a serious problem to get rid of them and plant again healthy or resistant varieties. If the latter thing happens, the expenses of replacing the field with other varieties will be very heavy, while if on the contrary the former happens, the benefit to the central will be enormous. Which of these two alternatives will ultimately prevail?

I am rather inclined to take an intermediate position. Diseased S. C. 12/4 has been found to suffer in its growth, although no effects of the disease have been found in the canes. A few generations of the disease conditions may affect the cane and consequently, the tonnage. B. H. 10–12 has thus far proven to be little affected by the disease. Whether this variety will ever degenerate or not, I am no able to state now.

No matter what the future results of these varieties will be, it has seemed wise to start nurseries of a great number of varieties of cane and practice "roguing" in order to have at hand sufficient quantity of healthy seed so that in case of a failure of the diseased B. H. 10–12 and S. C. 12/4, new fields of new varieties could be promptly planted. It has seemed that this is a very judicious measure which will only cost a few thousand dollars, but which may be of great help if not the whole salvation, in an emergency case.

While the writer was Sugar Technologist of the Insular Experiment Station there were started a series of field experiments early in 1922, the results of which will be discussed here. Later on, upon my appointment as head of the Department of Agriculture and Labor, Mr. Mariano Mari, an inspector of my department, took immediate direction of the experiments. During my absence they have been conducted with great care by Mr. Mari, who has exhibited great zeal an enthusiasm in the work. I am also under obligation to Mr. Andrés Oliver, president of Central Cambalache, for his hearty coöperation with the Department, and to Mr. José R. Aponte, for the valuable suggestions in connection with the work. Mr. Aponte's experiments with the mosaic since the early days of 1915 have been well known to the sugar planters of that region.

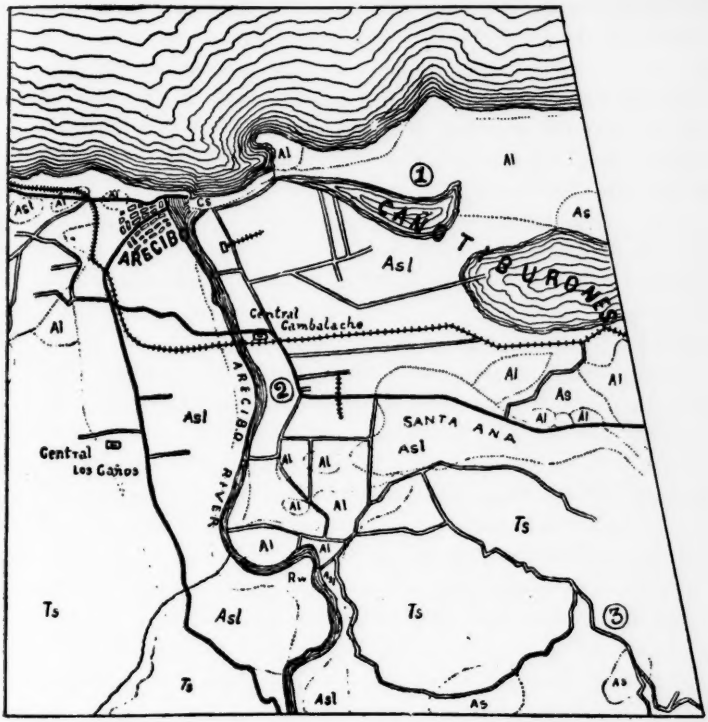
In the Arecibo valley there seem to be conditions favoring the spread of mosaic. In the first place, the soils are low, level and very fertile; cane grows well and it is a well-known fact that mosaic spreads more rapidly in fields where active growth is going on. In the second place, rains are frequent and heavy in certain portions of the year, weeds are very abundant and consequently, conditions are appropriate for the growth and development of *Aphis maidis*. The aphids have been found abundant on grasses in various fields. All these facts explain why it is quite common to find mosaic spreading rapidly in young plantations. With these adverse conditions prevailing, it was very difficult, if not impossible, to select a field for the nurseries where mosaic did not spread from adjoining fields. The selection of these fields for the nurseries needed to be determined with certainty before a large permanent nursery could be started.

In the Annual Report of the Insular Experiment Station for 1221–22, on page 68, the writer pointed out a condition which has later proven to be very helpful in connection with this work. It reads as follows:

"It has been observed that in regions of heavy infection, the percentage of infection in fields near the sea is remarkably low. This fact was very evident in Mayagüez, where fields planted to varieties other than Uba or Swinga, showed over 90 per cent infection or even higher. In a number of fields near the seashore at Guanajibo the mosaic infection was only 10 to 16 per cent, and in one case, a field near the Reform School, was as low as 6 per cent.

"The cause for this low infection is not clear, although the idea has been advanced that the wind from the sea carries particles of salt which are deposited in the leaves, and which serve as repelents against the insects that transmit the disease. It is also possible that the flora of these sandy areas, which are known to be very different from the flora of ordinary cane fields, might lack the necessary host plants of the insects that transmit the disease."

Whatever the cause for this low infection near the seashore may be, the fact is that conditions exist there which are unfavorable to the spread of mosaic. A whole search was made of fields of Cambalache in order to ascertain if this conditions was prevalent there. In this connection the Soil Map, published by the Bureau of Soils in 1902 and which covered a whole strip of soil 20 miles wide from Arecibo, to Ponce, was found very useful, a reproduction of which is here published (fig. 1). Three of its soil types are worth mentioning here:



Soil Map (From "Survey, Bureau of Soils, 1902")

Arecibo loam (Al), which covers portions of the north coast, especially east of Arecibo and bordering Caño Tiburones on the north. It consists of a black, tenacious loam of variable depth with a tenacious yellow loam for subsoil. This soil is considered of poor agricultural value, but bordering Caño Tiburones it is very deep and rich in organic matter, like the *poyales* of the south coast, and with ideal conditions for the planting of cane.

Arecibo silt loam (Asl) comprises the alluvial valley of the Arecibo river and one of the most important agricultural regions of Porto Rico. It is rich brown, silty loam of great depth and uniformity. It is all planted to sugar cane for centrals Cambalache and Los Caños and cover several thousand acres of excellent soil.

The *Tanama stony loam* (Ts) is a red, tenacious loam which is abundantly found in the terciary *pepino* formation, as a result of the weathering of the original limestone plateau which extended from Martín Peña to Aguadilla and far into the interior of the Island. The soil is rather poor and was all planted to bananas and minor crops, but wherever communications are easy they are now planted to sugar cane.

The percentage of mosaic infection in these three types of soils was found to be very variable. It may be assured that these peculiar conditions are not to be ascribed to the soils themselves, but rather to topographic and climatic condition which affect the rate of secondary infection. Thus the percentage of infection found in fields of the *Arecibo loam* was remarkably low, and thus coinciding with the writer's previous observation along the coast of Guanajibo. On the contrary, the fields in the Tanama stony loam were heavily infected with mosaic, and the only variety which deemed to thrive well here was the D–109. Intremediate conditions were found prevalent in the *Arecibo Silt Loam*, although, as was stated before, the B. H. 10–12 and S. C. 12/4 were heavily infected.

With the purpose of ascertaining experimentally these facts, three fields were selected representing these three types of soils: Field A, in the *Arecibo loam*, Field B, in the *Arecibo silt loam*, and field C. in the *Tanama stony loam*. They were carefully prepared for planting, using the *banco y carril* system, which consists of double rows separated by deep drainage ditches, the holes being 6' mult 5' in the banks. Two seeds were planted in each hole.

The field comprised over half an acre of the *Arecibo loam* type and was a few hundred yards from the shore of Caño Tiburones. It was a black loam with high organic content and excellent for growing cane.

The field was planted to 8 standard varieties of cane from the Insular Experiment Station on March 14, 1923, and harvested December 31, 1923, when the cane was a little over nine months old. The standard variety of that region being Yellow Caledonia, rows this variety were planted alternating with the varieties to be tested. Four plants of each variety were left standing to obtain sucrose mill tests at the end of a year. The results were as follows:

Variety	No. of plants	Diseased	Infection	Field	Sucrose [1]	Purity
Rayada..	70	1	1.42%	24.24 tons	15.03	90.81
D-117.....	40	1	2.50%	32 40	13.15	81.67
P. R.-412	136	1	0.72%	38 23	11.58	74.90
P. R.-414.....	52	2	3 86%	36.54	13 54	81.56
Cristalina.....	50	1	2.00%	36.00	15.48	89.22
B-3412.....	48	1	2.09%	41 65	12.68	81.80
P. R.-433	34	1	2.94%	44.12	16.87	91.19
S. C. 12/4.....	35	2	5.61%	42.85	15.94	90.10
Caledonia	372	4	1.12%	39.73	13.04	81.42

[1] The sugar tests were made March 23, 1924, by the chemist of Central Cambalache, Mr. Román Benítez, with the laboratory hand mill.

The average infection in field 1 is 1.67 per cent, that is, out of 838 plants only 14 became infected. This is remarkably low, especially if the percentage of infection is compared with those of fields II and III. These results corroborate the idea that regions near the seashore are practically free from mosaic and are consequently ideal for the propagation of selected varieties which are to be extensively used in the field later on.

A point of interest which must not be overlooked here is the fact that the variety P. R. 433 surpassed all the others both in yield and sugar content. It has behaved so far, as one of the most promising canes of the P. R. series.

FIELD II

One and a quarter acre of soil, adjoining the Arecibo river on the east bank was selected as the land more suitable to a nursery. It was formerly pasture land, and approaching virgin conditions more than any other place in the whole region. On account of its proximity to the river it was never known to have grown cane before. The soil was a good representation of the well known *vega* lands of Arecibo, the *Arecibo silt loam.*

The field was very well prepared in the usual *banco carril* system but drainage ditches were not found necessary. Twenty-one varieties were brought from the Insular Experiment Station and planted March 15-17, 1923. They well harvested at various intervals from November 21 to December 15 of the same year; that is, barely nine months old. No sucrose tests were made with the varieties, but a careful count of secondary infection was made. Diseased plants were "rogued" out systematically and a complete record

SELECT VARIETIES OF BARBADOS AND DEMERARA

B. 3405

B. 3412

D. 109

D. 117

of the infection of each variety was made. The following results of infection and tonnage were obtained:

Variety	No. of plants	Diseased	Infection	Yield
D.-109	60	7	8.75%	48.33 tons
P. R.-662	45	2	3.03%	25.00
P. R.-649	36	9	14.28%	27.77
S. C. 12-4	52	6	5.89%	50.95
P. R.-545	45	8	13.79%	44.09
B. H. 10-12	60	7	9.46%	50.00
B.-3405	66	15	15.62%	54.54
D.-625	42	11	18.96%	45.23
P. R.-329	86	8	7.61%	30.23
P. R.-507	33	1	2.17%	31.25
B.-208	60	16	18.18%	43.33
B.-3412	62	16	16.16%	53.22
P. R.-414	78	7	7.21%	56.92
P. R.-561	86	19	18.09%	60.70
D.-117	65	15	17.24%	43.75
B.-3696	55	8	11.57%	42.59
P. R.-440	67	7	8.75%	53.03
P. R.-328	71	21	16.28%	57.14
P. R.-433	116	13	7.28%	53.10
P. R.-412	73	13	9.92%	47.22
P. R.-492	45	10	16.12%	63.72

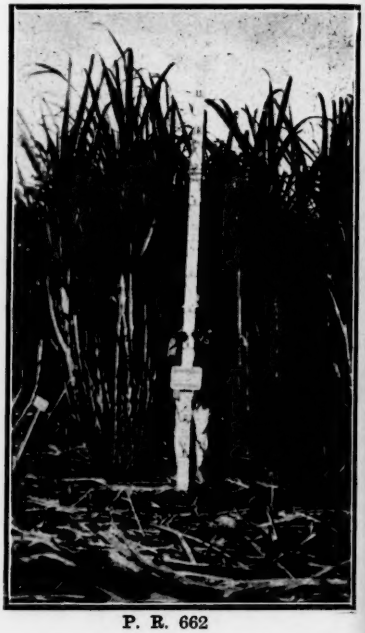
Out of 2,103 plants, 219 became infected, or 10.41 per cent. From the above figures it is impossible to deduct the relative resistance of each of the varieties to the mosaic, but it is apparent that there is a great variation in their susceptibility. Much light has been thrown on the question of resistant varieties by the researches of Prof. F. S. Earle. Had not "roguing" been practiced on this field, the percentage of infection would have been much higher, perhaps double or more.

The enormously high yields of many of the above varieties only 9 month old, are due to the high fertility of the soil. Had some of these varieties reached maturity and been allowed to grow for 15 or 16 months, their yield might possibly have established record production for Porto Rico.

The B. H. 10–12 and S. C. 12/4 looked fine, but were exceeded in tonnage by a number of other seedlings P. R. 651, P. R. 328, P. R. 440, and again, P. R. 433 were heavier yielders than B. H. 10–12 and S. C. 12/4, but it is doubtful whether their sucrose content was higher. B–3405 and B–3412 did very well also, but experience elsewhere has shown that they are too late maturing and low in sucrose.

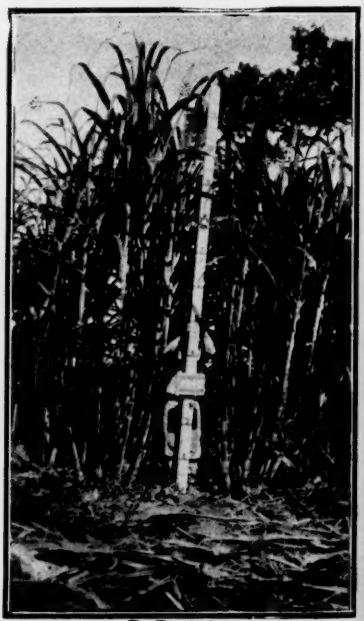
SELECT VARIETIES OF PORTO RICO
(Produced at the Experiment Station, Río Piedras)

P. R. 561



P. R. 662

P. R. 402



P. R. 414

Some of the best varieties are shown in figs. 2 and 3, accompanying this paper.

As a result of this experiment it may be safe to conclude that the *vega* soils of Arecibo are not appropriate for nursery plantings since the plants are very likely to get infected secondarily.

FIELD III

This field comprised about one-tenth of an acre and a place where a former "corral" of cattle was located, was selected. Although the soil was rather poor, being of the characteristic *Tanama stony loam*, it was improved with animal manure. The manure very materially improved the physical texture of the soil.

On March 18, 1923, the following varieties were planted, using healthy seed from the Insular Experiment Station: D–625, P. R. 561, P. R. 328, P. R. 433, D–117, B–3696, P. R. 545, P. R. 417 and P. R. 412. A few cases (6) were noticed in May 25 and the diseased plants pulled out immediately. The next infection was made in June 14, when 69 plants out of 471 were found infected or 14.6 per cent infection. The spread of the disease was so rapid in July and August that it was impossible to keep a record of the infection. In December, about 90 per cent of the plants were infected.

Thus the attempt to establish a nursery in this region of the interior of the Island failed utterly. Variety P. R. 412 completely broke down under the effects of the mosaic. The other varieties were more or less affected.

As a result of this convincing test it seems to be hopeless to attempt nurseries in the interior regions of the north coast. Observation has shown that the best variety for this zone is D–109. Uba and the P. O. J. seedlings (with the exception of P. O. J. 105) are heavy yielders here. B. H. 10–12 and S. C. 12–4 do not thrive well under these conditions.

CONCLUSIONS

1. The practice of planting extensively B. H. 10–12 and S. C. 12–4 in the alluvial soils of the north coast of Porto Rico without taking the necessary precautions against mosaic has become a common practice.

2. The yields have increased greatly but a large percentage of the plantations are diseased. These diseased fields do not show any

FAMOUS VARIETIES SANTA CRUZ 12/4 AND HYBRID BARBADOS 10/12

These two varieties, because of the tonnage and sugar yield, are the most favored among our planters.

decrease in production which may be ascribed to mosaic and the ratoons are developing normally and vigorously.

3. It is not known whether these two varieties will in the future exhibit the same degree of resistance that they have shown so far. It seems logical that they will begin to break down in the next few years.

4. Extensive nurseries need to be started in order to have sufficient healthy seed at hand in case there is need of a rapid replacement of the B. H. 10–12 and S. C. 12–4 for other varieties.

5. Experiments in three different regions representing three soil types and three different climatic and topographic conditions disclose the fact that in certain *poyal* lands near the coast the mosaic disease is held in check by unknown adverse condition.

6. These regions seem to be most suitable for establishing the nurseries of different varieties which in the future may meet a disaster or an emergency.

This preliminary report covers only the first year's experience with mosaic at Central Cambalache. Following conclusion No. 6 above stated, a large nursery of 26 acres comprising 52 varieties was planted north of Caño Tiburones, adjoining former field I. The results of the second year's experience will be published later, but as a matter of information it may be said that the percentage of infection in these 26 acres has been so far only 0.43 per cent. These results from the second year's experience show that it is safe to propagate varieties on a large scale in this region.

The benefit which may be derived by the central from these 26 acres of healthy seed is something which the future will decide. Will it be a worthless expenditure of money or will it turn out to be a deciding factor in the years to come?

AN INTERESTING CASE OF BOILER-TUBE CORROSION

By F. López Domínguez and R. Fernández García,
Chief and Associate Chemists, respectively, Insular Experiment Station

In the month of February of the present year, the Insular Experiment Station was informed by the manager of one of the sugar factories of the Island that an unusual corrosion had been taking place in their boiler tubes and that so far they had been unable to find the cause for it, or an appropriate method for its control. They requested, therefore, that the case be investigated by the Station.

Complying with orders of the Director we proceeded in his company to visit the factory, where the following information was obtained:

1. For fourteen years they had been using to feed their boilers, which are of the fire-tube type, water from a stream flownig by the factory, mixed with condensation water from the evaporators, and for the boilers of the locomotives, water from the stream exclusively.

2. The observation was made that there were incrustations left by these waters, and to prevent this they decided to cover the tubes of the factory boilers with graphite paint. This practice was begun in the year 1917.

3. By the end of 1923 on inspecting the factory boiler tubes, some of them were found to be badly corroded; new tubes were then substituted for these corroded tubes.

4. Shortly after the beginning of the 1924 crop a very rapid corrosion of the tubes was noticed. This went to such an extreme that a new set of tubes was ordered from the States. They estimated the expenses incurred on account of this trouble, including the new order for tubes, at $20,000.

5. The tubes of the locomotive boilers, on the other hand, in which only stream water was used, showed no sign of corrosion but, on the contrary, they were found to be covered with a thick crust of mineral residues. On first consideration of the problem, then it looked as if the corrosion might be due to acidity in the condensation waters, since the water from the stream was capable of forming incrustations. With this idea in mind, we proceeded to take samples of the condensation waters from the evaporators and from the feeding tanks as well as from boilers 1 and 3, the only ones containing water

which had not been changed for the last 24 hours. As additional sources of information we also took samples of the waters from the stream and of the crust found in the tubes of the locomotive boilers.

The water samples from the boilers were of a dark color with a green tinge, and contained black particles in suspension. It was in explanation of this that we were informed that graphite paint had been used in the tubes and that this was the cause of the color of the water.

The samples were brought to the laboratory and the following tests were made:

1. Alpha naphtol tests for sugars in the condensation waters and in the water from the feeding tank. All tests negative.

2. Acidity in 10 cc. of water:

Boiler No. 1	9.1 cc. of n/100 Na OH
Boiler No. 3	30.5 cc. of n/100 Na OH
Quadruple effect	Clean transparent water without traces of oil
Evaporator No. 1	0.54 cc. of n/100 Na OH
Evaporator No. 2	0.22 cc. of n/100 Na OH
Evaporators Nos. 2, 3, 4 mixed	0.35 cc. of n/100 Na OH
Feeding tank	0.84 cc. without traces of oil

3. Iron in solution in parts per million:

Boiler No. 1	0.216 cc. Fe_2O_3
Boiler No. 3	0.264 cc. Fe_2O_3

4. Analysis of water from the stream:

Loss on ignition	102.0 parts per million
Bicarbonates HCO_3'	103.1 parts per million
Sulphates SO_4''	6.5 parts per million
Chlorides Cl	18.7 parts per million
Sodium Na'	18.8 parts per million
Calcium Ca''	14.7 parts per million
Magnesium Mg''	4.1 parts per million
Aluminium Al_2O_3	4.0 parts per million
Silica $Si\ O_2$	34.1 parts per million

5. Incrustation from the locomotive boilers:

Qualitative analysis: Iron, calcium, aluminium, magnesium and silicon present.

The foregoing data show:

1. That there was no sugar going to the boilers in the condensation waters.

2. That the acidity found in the water of the evaporators was too small to account for the trouble observed, inasmuh as the accumulation of acids was avoided by frequently changing the water of the boilers. Notice, however, that the acidity is greater in the feeding tank and greater in evaporator No. 1 than in the rest. This shows that there were acids going into evaporator No. 1 as well as into the feeding tank carried there by the exhaust steam; but in proportion, however, as will be seen later, much lower than those found in the boilers.

3. Boiler No. 3 showed an acidity three times as great as Boiler No. 1, which shows that the cause whatever it might be, was acting with greater intensity in Boiler No. 3. This is confirmed by the figures found for the iron content of the boiler waters, which was higher in the case of the samples taken from Boiler No. 3.

The analysis of the stream water as well as the examination of the locomotive incrustations shows what we already suspected, that this water was not capable of causing corrosion.

It has been proven, then, that the corrosion was not due either to the condensation waters or to the stream water, and we therefore were compelled to give up our first theory that the corrosive agent might be taken to the boilers by the feeding waters. We were then forced to the conclusion that the cause was in the boilers themselves.

Looking then for another explanations of the facts, we remembered that the boiler waters, on being shaken, formed a great deal of foam which stayed for a long a time and had the appearance of soap suds. This gave us the key to the situation. What could be the cause of the foam? There were not enough alcaline salts in solution to account for its formation, as on the contrary the waters were acid. Was there any soap in dissolution? How could the soap get there? There was a possibility. If the paint used in the tubes had been prepared with a vegetable fat, these might very well be partly saponified by the bicarbonates of the stream water. Then we remembered that linseed oil is very frequently used in the preparation of graphite paint. If this was so, we ought to be able to find in the water from the boilers, the products of decomposition of linseed oil and, furthermore, they should be fatty acids capable of dissolving iron under the condition of the boilers. With references to this possible decomposition says Fox, referring to the alterations undergone by linseed oil on being subjected to boiling temperature,[1] "the oxi-

[1] Allen Comm. Organic Analysis. Vol. 11, page 344, Fourth Edition.

dation products are formed from the acids and the glycerol is decomposed into acids of the acrylic series, forming the irritating vapors which always accompany oil boiling. Acetic and formic acids are prominent constitutents of these vapors, and carbon dioxide and water are also present." To verify this theory we visited again the factory to get new samples and to obtain more information. On questioning the engineer, we were informed that the graphite paint had been prepared of late, some times with mineral oils and some times with linseed oil. We were also informed that boiler No. 3 had been painted this year when the tubes were changed, and that boiler No. 1 had been painted for the last time the previous year. We were as well informed that the live steam from the boilers on condensing in the low places of the steam pipes, caused corrosion.

We proceeded to take samples of the water from the boiler No. 3 and of the linseed oil and graphite used in the preparation of the paint.

The linseed oil was tested for acidity as follows:

3. cc. of oil were mixed with 300 cc. of water and the mixture shaken at intrevals for an hour. At the end of this time 25 cc. of the mixture were titrated with n/100 Na OH after the mixture had been filtered. In the same manner portions of 25 cc. each were titrated two days, four days, and six days later respectively. The results were as follows:

After one hour	0.33 cc. N/100 Na OH
Two days after	0.73 cc. N/100 Na OH
Four days after	1.47 cc. N/100 Na OH
Six days after	2.88 cc. N/100 Na OH

The oil as may be seen, contained free acids, which entered in solution almost in direct portion to the time of contact between the oil and the water. This rather indicates a process of hydrolysis. In the waters of the boilers, tests were made for acetic acid by the acetic-ester method and for formic acid by the reduction of silver nitrate; both tests were positive. As a direct proof we undertook to study the behavior of the linseed oil under the conditions existing in the boilers, duplicating these as far as possible in the laboratory. Accordingly, we heated for 5 hours in an autoclave under 30 pounds pressure in closed bottles the following mixtures:

1. 300 cc. distilled water plus 3 cc. oil
2. 300 cc. distilled water plus 3 cc. oil plus 1 gram graphite
3. 300 cc. distilled water plus 3 cc. oil plus 3 grams iron

4. 300 cc. distilled water plus 3 cc. oil plus 3 grams iron plus 1 graphite
5. 300 cc. stream water plus 3 cc. oil plus 3 grams iron
6. 300 cc. distilled water plus 6 cc. oil

These mixtures were filtered after being taken out of the autoclave and the filtrates were tested for acidity and for iron. In all cases in which iron was added, a positive test was given by the filtrate for this element. The titrations were as follows:

1. 25 cc. filtrate.....3.59 cc. n/100 Na OH
2. 25 cc. filtrate.....3.48 cc. n/100 Na OH
3. 25 cc. filtrate.....3.37 cc. n/100 Na OH
4. 25 cc. filtrate.....3.70 cc. n/100 Na OH
5. 25 cc. filtrate.....3.33 cc. n/100 Na OH
6. 25 cc. filtrate.....6.30 cc. n/100 Na OH

In filtrate No. 6 positive tests were obtained for acetic and formic acids. These new data prove the presence of the products of decomposition of linseed oil in the boiler waters, as positive tests for these products were obtained both in the samples taken from the boilers and in the mixtures prepared and heated under pressure at the laboratory.

It was further proved that the acids formed were capable of dissolving iron, as was seen by the positive tests for this metal obtained in the filtrates of the mixtures containing this element. Notice again that the acidity of flasks 1, 2, 3, and 4 with distilled water and 3cc. of oil each, were far nearly the same, whereas the filtrate from test No. 6 with a double amount of acid contained an acidity which was practically twice as great. In flask No. 5, in which stream water was used, the acidity was much lower, showing that part of the acids had been saponified by the bicarbonates present in the waters. In regard to this it should not be forgotten that boiler No. 3, recently painted, was the one which presented the highest acidity; this may be explained by the fact that it contained more oil than boiler No. 1, which was painted the year before.

The higher acid content of evaporator body No. 1 and of the feeding tank are also explained, as the volatile acids formed in the boilers would pass to the steam pipe and would be carried over by the steam after going through the cylinders of the engines to the *calandria* of the first body of the evaporator. This acidity of the live steam is demonstrated by the corrosion which it produced in the steam pipe and the valves.

The possibility of the exhaust steam pipes carrying vegetable

oils washed from the cylinders as the possible cause of the acidity noticed, did not escape our attention; but upon inquiry from the factory engineer we were assured that all the lubricants used in the factory were of a mineral nature.

Accordingly, we considered it unnecessary to investigate this point further, chiefly when the sample of the condensation waters from the *calandria* of the first body of the evaporator was very clear and did not present any signs of oil. Having satisfied ourselves that the corrosion in this case was due to acids produced by the decomposition of the linseed oil used in the preparation of the paint applied to the boiler tubes, we recommended that as soon as the factory made a stop these tubes should be washed with a boiling solution of caustic soda and in the meantime that lime should be used in the feeding waters to neutralize the acidity in the boilers. This, we were informed, the factory engineer had begun to do. Also that on installing the new tubes the paint should be prepared with a mineral oil. The above discussion may be summarized as follows:

1. Upon testing the stream water and the condensation water, sources from which the feed water was supplied to the boilers, no corrosive agents were formed which could account for the trouble observed. It was evident, then, that the cause was in the boilers themselves.

2. Upon testing the boilers' waters they were found to contain a very high acidity as well as considerable amounts of iron in solution. It was also noticed that they formed a foam which very much resembled soap suds. This led us to believe that the graphite used to cover the boiler tubes had been prepared with a vegetable fat, probably linseed oil.

3. On investigating the kind of acids found in these boiler waters, they were found to be organic acids (acetic and formic). On inquiry from the factory engineer, we were informed that linseed oil had been used.

4. To verify our conclusions we duplicated as much as possible in the laboratory the conditions which we supposed had existed in the boilers, heating under pressure mixtures of water and linseed oil; water, linseed oil and iron; water, linseed oil, iron and graphite In every case we have obtained the formation of organic acids of the same nature as those found in the boiler waters, and in every

case in which iron was present in the mixture a positive test was obtained for this metal in the filtrates from the solutions.

5. The recommendation was made that the lime be used in the feed water, to neutralize the acidity in the boilers; that the tubes be washed with boiling caustic soda solution to remove the paint, as soon as the factory made a stop, and that when new tubes were installed the paint be prepared with kerosene oil.

DETERMINATION OF MACERATION PER CENT OF CANE AND THE PERCENTAGES OF FIBRE AND SUCROSE IN CANE

By José J. Acosta, Factory Superintendent, Central "Juncos"

The well-known difficulties experienced in obtaining a representative sample of the cane ground in a sugar factory make it inconvenient to determine the percentage of fibre and sucrose in cane by direct analysis of the latter, and accordingly, these items are estimated from the data of juice and bagasse analysis, and the weights of cane, mixed juice, and water of maceration.

Sucrose in cane is equal to the sum of sucrose in mixed juice and sucrose lost in baggase. The sucrose in mixed juice is easily obtained from the weight and analysis of said juice; but the sucrose lost finding the weight of the water of maceration. Factories under these conditions can use only one method for calculating percent fibre and sucrose in cane. This method is clearly explained on page 553 of the last edition of Noel Dee's "Cane Sugar."

The following data are daily obtained in these factories:

C = Tons of Cane ground
G. M. = Tons of Mixed Juice extracted
B^m = Brix of Mixed Juice extracted
B^n = Brix of Normal Juice
B^b = Brix in bagasse per cent bagasse, obtained by dividing the per cent sucrose in bagasse by the purity of juice from the last roll
F % B = Fibre per cent bagasse obtained from the per cent moisture in bagasse and Brix in Bagasse per cent Bagasse.

If T. F. represents the tons of fibre in cane we have:

C — T. F. = Tons of normal juice in cane.
(C — T. F.) B^n = Tons of Brix in cane. Also the Tons of Brix in cane is equal to the sum of Tons of Brix in mixed juice and Tons of Brix in Bagasse.

Then:

$$(C - T.F.)\ B^n = G.M. \times B^m + \frac{B \times F}{T.F.} B^b;\ \text{or,}\ C \times B^n + T.F. \times B^n = G.M. \times B^m + \frac{T.F. \times B^b}{F\ \%\ B}$$

Transposing:

$$\frac{\text{T. F.} \times B^b}{\text{F \% B}} + \text{T. F.} \times B^n = C \times B^n - \text{G. M.} \times B^m$$

$$\text{T. F.} = \frac{(C \times B^n - \text{G. M.} \times B^m)\ \text{F \% B}}{B^n \times \text{F \% B} + B^b}$$

Knowing T. F. or the tons of fibre in cane, the weight of bagasse is determined.

$$\text{Tons of Bagasse} = \frac{\text{T. F.} \times 100}{\text{F \% B}}$$

We have been using this method for determining percent fibre and sucrose in cane.

Commonly a factor or coefficient is used either to multiply or divide the percent dilution so as to obtain the percent of maceration. Most of the chemists in Porto Rico divide by 0.85 while others multiply by 1.1669.

As Noel Deer's method is so logical, and the factor or coefficient method so inaccurate, we believe the former method is more exact.

It is argued that the factor for calculating maceration or dilution is carefully determined using sensitive and exact water meters.

We believe that it is a dangerous procedure to assume that a factor obtained while a certain variety of cane, that may be of either plant or rattoon crop and of a given age, in mills adjusted for the occasion and revolving at a certain lineal velocity, should be taken as true for all canes and all conditions of the mill. It is still more dangerous to apply such factor to another mill or another factory.

Suppose all these variables do not affect the ratio $\frac{\text{Dilution}}{\text{Maceration}}$; or in other words, suppose that cane and mill conditions be the same; then, it would not be right to take this ratio as constant when in fact it varies when the amount of maceration is varied.

The coefficient method in vogue implies that the quantity of water retained by the bagasse varies with the quantity of maceration used. We are contrary to this belief, for if cane and mill conditions are constant, the quantity of water retained or absorbed by the bagasse is constant when maceration exceeds a determined minimum. Maceration can be diminished to a point where the mill would not extract the added water, thus allowing it to pass entirely to the bagasse.

Representing maceration by m and the quantity of water re-

tained by bagasse by c, a constant, we have that dilution is m–c and $\frac{\text{dilution}}{\text{maceration}} = \frac{\text{m–c}}{\text{m}}$ It is obvious that this term, far from being a constant, is a variable and varies directly with m while changing the quantity of maceration.

We installed this year at Central Juncos a General Electric flow-meter for measuring maceration water, and although the meter did not work constantly, we had opportunity to check the results obtained with Noel Deer's formula at such times as the meter was working right.

We must insist in the installation of scales for weighing the maceration water. I say scales, because the meters in spite of being exact when they work right, get stuck frequently and cannot be depended upon for continuous work. I beg to recommend the use of Noel Deer's formula when a scale is not available so as to obtain uniform and comparative results in different factories.

Let us not be satisfied with weighing the canes and the juice only; let us weigh also the water of maceration so as to eliminate from our reports the extraction and analysis of the imaginary normal juice, and be able to abolish the use of factors, rather doubtful, and the use of formulae which increase unavoidable errors. In this way we could come closer to the real sucrose per cent in cane—the most important factor given in a laboratory report on which to base judgment on the work done in a factory.

PRESENT KNOWLEDGE OF MOSAIC DISEASES

By MELVILLE T. COOK, Pathologist, Insular Experiment Station

The mosaic diseases of plants have become very prominent within the past few years. No doubt these diseases have existed for many years but they may not have been so widely distributed or so destructive as within recent years. Certainly no group of plant diseases known to modern science have proved so mysterious or so difficult to control as these "mosaic" diseases. In fact the causes are as yet unknown unless the recent studies to which I shall refer prove to be an open door to this phase of the subject.

A number of terms have been used to designate the disease which is now so generally known as "mosaic". This term has come into very general use because it is in itself descriptive of the diseased plants. Another type of disease which appears to be of the same general character but which does not show the markings is known as "yellows". However, this term is not so descriptive because diseased plants are not always yellow and because the term "yellows" is applied to some diseases which are caused by fungi. "Curly leaf" of beet, "leaf roll" of potato and some other diseases are probably similar in character to the mosaic disease.

Although these diseases did not attract much attention until within the last quarter of a century, they have no doubt been important factors in plant production for a very long time. Unfortunately, some of the early descriptions are of such character as to leave us in doubt as to the disease in question. However, some of them are sufficiently definite to lead us to believe that "peach yellows" was known to the growers as early as 1797. Swieten mentions a disease of tobacco which was probably "mosaic" in 1857 and which was known for some time as "rost" or "Fleckenkrankheit". This appears to be the first definite record of a mosaic disease on any plant. The "mosaic" disease of tobacco was studied by Adolf Mayer in 1885 and he gave it the name of "mosaic". For many years, tobacco mosaic occupied the centre of the stage, but the discoveries of mosaic in other plants and its recognition as a very severe disease on many crops, such as sugar cane, potatoes and tomatoes, have directed our studies along broader lines.

The "mosaic" of sugar cane was reported from Java in 1890 under the name of "*gele strepenziekte*" or "yellow Stripe". In 1909 it was reported from Egypt on cane imported from Java. In

1910 it was reported from Hawaii. It was first reported from Porto Rico in 1916 and its spread and destructive characters are so well known that it is not necessary for me to discuss them at this time.

In fact it is the purpose of this paper to give a review of our knowledge of mosaic diseases in general, with special attention to the cane mosaic. A paper by Commissioner Carlos E. Chardón on this same general subject was published in *Revista de Agricultura de Puerto Rico* in October 1922, but it was considered advisable by both Mr. Chardón and the speaker to present the subject again at this time.

The cause of the disease is the question which is uppermost in the minds of all observers. We will give a brief discussion of the theories which have been advanced from time to time.

1. *Bud variation theory.*—It is well known that many species of plants are subject to very great variations, both through the seeds and through the buds. In fact it is through the selection of the most desirable variations that we have obtained many of our most valuable cultivated plants. Sugar cane is very generally known as a plant subject to many variations. The Dutch scientific workers in Java who were the first to report mosaic of the sugar cane, having failed to transmit the disease by means of artificial inoculation, came to the conclusion that it was not a disease in the usual sence of the term but a bud variation. However, they recognized that these supposed bud variations, which were in reality cases of mosaic, were undesirable. Therefore, they made an effort to get rid of them and unconsciously practiced elimination of the diseased or undesirable plants and the selection of the resistant varieties.

2. *The soil theory.*—The influence of the different kinds of soil and fertilizers on plant growth is so very generally recognized that many people very naturally took in that direction for the explanation of both good and evil. The results of studies on this line have been such that it is now very generally recognized that the causal agency does not lie in the soil or in the use of fertilizers.

3. *The bacterial theory.*—The rise of bacteriology by which so many diseases were explained very naturally led many to believe that this important science would give us the key to this disease. The idea that bacteria were the cause of the mosaic of tobacco was first advanced by Mayer (1886). This theory was supported by Iwanowski (1892) (1901) (1903); Prillieux and Delacroix (1894); by Marchal (1897); by Koning (1899, 1900); by Breda van Haan

1899); by Behrens (1896); by Hunger and others. Some of these workers obtained and described what they believe to be the causal organism. Unfortunately, no definite proof was obtained.

4. *Protozoa theory.*—Although the bacterial theory has not been proven there are many who believed that these diseases might be due to an organism with a life cycle somewhat similar to that of the organisms causing the yellow and malarial fevers.

In 1903 Iwanowski found bodies which he thought might be the cause of the mosaic in tobacco, but no proof was forthcoming and his work did not attract much attention until recently. In 1919, Matz found what he at first claimed to be an organism in mosaic sugar cane in Porto Rico, but he later found reason for doubting his first claims. In 1921 Kunkel reported the finding of protozoan-like bodies in corn mosaic and later in cane mosaic. It was thought that these bodies might possibly be the cause of the disease but as yet there is no definite proof. In 1922(?) Nelson reported the finding of protozoan-like or trypanosomelike bodies in tomato and other plants infected with mosaic. Later studies show that similar bodies are to be found in apparently healthy tissues.

In 1923, McKinney, Eckerson and Webb reported the finding of bodies in wheat rosette and mottled wheat. The speaker has been making studies on sugar cane in Porto Rico along similar lines as the studies of Iwanowski, Kunkel, Nelson, McKinley, Eckerson and Webb. Bodies similar to those reported by these workers have been found. There are also certain other very pronounced differences between the cells from normal and diseased cane. Whether these bodies which have been reported are the causes of disease or the results of the disease is a problem which is as yet unsolved.

5. *The physiological theory.*—This was at one time more generally accepted than any other theory. It was developed in connection with the study of the tobacco mosaic. Sturgis in 1899 expressed the belief that the disease might be due to injuries or to soil and atmospheric agencies. Hunger (1903, 1905) stated that it was due to a disturbed metabolism which might be the result of metereological or soil conditions. Westerdijk (1910) called attention to certain data indicating that it might be due to intensity of light.

While it is very doubtful if the cause is to be found in the soil, temperature, light or moisture, the study of these factors must not be neglected. Even though they may not be the causal agents they may influence the severity of the disease.

The causes of wheat rosette and wheat mottle, whatever they may be, are said to persist in the soil. Temperature is an influential factor in potato mosaic and there is evidence to indicate that moisture is an influential factor in cane mosaic. All of these factors must be studied in connection with cane mosaic.

6. *The enzyme theory.*—This theory was adhered to by Woods and others and was closely associated with the physiological theory. This theory as briefly stated by Woods is: "The disease is not due to parasites of any kind, but is the result of defective nutrition of the young dividing and rapidly growing cells, due to a lack of elaborated nitrogenous reserve food accompanied by an abnormal increase in activity of oxidizing enzyme in the diseased sells." Woods also found an excessive accumulation of starch in the diseased plants and a defective translocation of same. He believed that the excessive amount of oxidases inhibited the diastatic action on the starch and thus resulted in its excessive accumulation. The excessive accumulation of starch and reduced translocation was demonstrated for "peach yellows" by the speaker and the results published in the *Botanical Gazette*, but this does not prove that the enzyme theory is correct. The speaker is now making similar studies on the sugar cane. The studies up to this time indicate some very interesting physiological disturbances, especially in connection with the photo-synthetic and metabolic activities of the plant. In brief, I may say that from the physiologic standpoint cane mosaic is "starvation" due to disturbed photosynthetic and metabolic activities. The cause of these disturbances are problems for further investigation.

7. *The virus theory.*—This theory was advanced by Beijerinck (1898), who had previously held to the bacterial theory. It explained the mosaic as due to a "*contagium vivium fluidum*" or contageous living fluid which was soluble, diffusible, living and capable of increasing in amount. This theory has been accepted by many and has been the basis of a considerable amount of research. This is still a fruitful line of study which is being followed in some places.

Regardless of cause it is very evident that the mosaic diseases can be transmitted from plant to plant. In the case of some plants, of which the tobacco is a notable example, the disease can be transmitted by contact or even by the handling of diseased and then healthy plants. In some cases it can be transmitted by pruning and in some cases by inoculation. In a number of cases it has been demonstrated that the mosaic diseases are carried from diseased to healthy plants

by insects. In the case of the sugar-cane mosaic successful work on this line has been carried on by Brandes, Ledeboer, Bruner, Kunkel, Chardón and Veve. In some few cases there is evidence to indicate that the disease can be transmitted between plants of different species. It has also been demonstrated that the mosaic disease of some plants may be carried by plants of an entirely different species without showing it.

PRESENT STATUS

Our knowledge of mosaic diseases in general may be summarized as follows:

1. Mosaic is a term applied to diseases of plants which cause a mottling or striping of the foliage.

2. This disease also frequently causes a dwarfing of the plant and sometimes reduction of certain parts.

3. Some of the diseases known as "yellows", "curly leaf", "leaf roll", etc., are very similar in nature to the mosaics.

4. The disease in many plants is transmitted by insects.

5. The disease on cane spreads most readily during wet weather.

6. The cause of the disease is not definitely known.

7. Recent studies by Kunkel indicate that diseased plants may recover.

8. The disease may be carried on apparently healthy plants and sometimes in plants of entirely different species.

9. There is some evidence to indicate that the disease may be due to an organism.

Future lines of work are as follows:

1. More extensive and exact field studies to determine susceptibility, of varieties, spread, effects of soil, cultivation, character of seed, etc. These studies will require a long period of time.

2. Histological studies to determine possible cause and effects on the plants.

3. Physiological studies to determine the effects of soil, fertilizers, temperature, light, moisture and other factors on the disease.

4. Studies on transmission to determine the insect carriers and their life histories. Also the extent to which the disease is carried in other species of plants. Also to determine the possiblity of its being carried in supposedly immune varieties.

5. There is no evidence that any of the mosaic diseases are caused by soil conditions or can be transmitted through the soil, although the mottle disease of wheat is said to persist in the soil.

SUGAR-CANE LEAF SPOTS IN PORTO RICO

By MELVILLE T. COOK, Pathologist, Insular Experiment Station

The leaf-spot diseases of sugar cane are very abundant and conspicuous and undoubtedly cause far more losses than are attributed to them. In fact, they are so common that we have neglected to give them the proper attention.

These spots, with the exception of the mosaic, are very generally caused by fungi, and the most abundant leaf spots in Porto Rico are caused by *Leptosphaeria sacchari* and *Helminthosporium sacchari.*

When the writer first came to Porto Rico in July 1923, his attention was called to two apparently new leaf-spot diseases which were causing considerable alarm among the sugar-cane growers.. One which was found at Manatí and later at other points along the north coast was temporarily designated as the "Manatí disease". It was most severe on D–109 but has also been found on D–117, B–3412, F. C. 214, D–433, P. R. 260, P. R. 430, S. C. (12) 4, P. R. 561, P. R. 412. The other was found at Santa Rita only and on B. H. 10(12). It was temporarily designated as the "Santa Rita disease". It has since been found on some other varieties. Their disease may be described as follows:

MANATÍ DISEASE

This disease starts as very small reddish, occasionally black spots. If red, a black centre develops very quickly. The spot becomes very much elongated but usually remains narrow. The centre is surrounded by a yellowish zone which may be light green or almost white. These colors grade or blend into each other and vary greatly in relative amounts. Some of the spot remains red until one-fourth inch in length before showing the black center. Any one of the three colors may predominate. When the spots grow old, they usually develop ashy-colored centers. They vary greatly in length from one-fourth inch to 3 inches or more. Occasionally they form reddish or dark-reddish stripes extending from base to tip of leaf, but these are probably the results of the unions of two or more spots. In the young spots the colors are usually bright and clear, but as the spots grow old the colors become dull and gradually disappear with the dying of the leaf. The spots may appear on any part of the

leaf from midrib to margin but do not occur on the midrib. They are much less severe on the sheath than on the blade. In severe cases the entire leaf with exception of the midrid is practically covered with these spots. The result is the death of the infected part and checking of the growth of the plant.

The sporophores are in clusters of from four to twenty, unbranched, 3–10 septate, dark green to brown or black, only slightly geniculate, 25 to 115 × 5 u. spore slightly curved, 5 to 11 septate, 45—110×12 u.

SANTA RITA DISEASE

This disease starts with minute reddish spots. As they advance, they may occasionally assume the same characters as those of the Manatí disease but usually are wider, blunt with very pronounced red color which gradually becomes more or less purple. In more advanced stages the spots are large and irregular in shape. This irregularity is apparently the result of the union of both old and young spots. The results is that the spots become very large and irregular in shape and sometimes include small spots of apparently healthy tissues. They may now be more appropriately called blotches. The color varies from red to dark purple, the latter color predominating. The surrounding tissue is usually pale yellow. The amount of purple blotches increases until it is far in excess of the green on the lower half of the leaf. The upper or outer half of the leaf shows very little or no spotting, but with the advancement of the disease on the lower half it becomes yellow and ashy brown. The sheath is finally attacked but not until the disease is well advanced on the blade. The result is a checking of the growth of the cane.

The sporophores are in clusters of from 3 to 6, unbranched, 6–10 septate, dark green to brown or black, straight or geniculate, bearing a single spore at each bend, 60–300×12–14 u. spores slightly curved, 4–10 septate, 30–95×12–15 u.

The preliminary studies did not show any considerable number of spores, but later it was found possible to secure the spores in great abundance.

The Manatí disease is very similar to *H. sacchari* as described by Butler in India (1913) which is probably the same *Cercospora sacchari* which was described by J. Van Breda de Haan from Jnva (1892) and by Cobb from Hawaii (1909). The Santa Rita disease shows greatre differences and may possibly be a new variety or a

new species. However, it may be that the peculiar blotching may be due to an entirely different cause or to a combination of causes. The studies of the speaker on the Santa Rita disease, have been carried on at considerable disadvantage.

Inoculation studies have been conducted with these two diseases on D–109 and B. H. 10(12). Both varieties are easily infected by either fungus, and in the young stages it is difficult to distinguish the two diseases, but in advanced stages the characters are more prominent.

As previously stated, the "Santa Rita disease" appears to be restricted almost entirely to the one variety and to the one locality on the Island. The "Manatí disease" varies in severity, locality, variety and humidity. In some cases it is no doubt the cause of heavy losses. It is very important that we make more extensive studies on these and other leaf spots to determine the susceptibility of varieties and the influence of environmental factors. In recognition of the importance of this work the Commissioner and the Director have authorized the installation of a small overhead irrigation system which will make it possible to pursue these studies.

These leaf-spot diseases may be taken as an index of what we are to expect in the way of plant diseases. The introduction of varieties of sugar cane from one part of the world to other parts means the carrying of diseases. A disease which may be of no imporance in one part of the world may become virulent in another part. In the development of new varieties these diseases must be taken into consideration. New varieties which possess the characters desired by the grower may not be resistant to disease. Finally, it must be remembered that the same laws which make possible the development of new varieties of sugar cane may also lead to the development of new strains of injurious fungi.

SOME NOTES ON TILE DRAINAGE ON THE SOUTH COAST OF PORTO RICO

By G. M. GILES, Manager, Central Mercedita

The use of tile drains in Porto Rico was first attempted, so far as the writer knows, at the Mayagüez Experiment Station some eight or ten years ago.

In 1921 while visiting that station a field was pointed out as having been drained several years previously. The drainage was so successful as to convert what had been a lagoon in wet weather, and a swamply soil in dry spells, into a fertile field which was planted to cane and was being cultivated by a wheeled cultivator drawn by mules.

This experience seemed worth emulating and it was decided to try similar work at Mercedita where there are numerous wet spots in many fields. These spots are for the most part salty as well as wet, due to the evaporation of excess irrigation water which is more or less charged with salts from the alkaline soils in the neighborhood.

On investigation it appeared that drain tile made in the States could not be imported at reasonable cost on account of excessive breakage. A hand-power machine was therefore secured for making tile from cement mortar. These machines are inexpensive and after a little practice an ordinary laborer with one helper can make from 250 to 350 tiles per day.

The mortar used is three-to-one mixture, and one bag of cement should make about 75 tiles four inches in diameter and one foot long.

After curing ten days or two weeks the tile can be handled and hauled to the field with but nominal breakage.

The depth and spacing of drains is a matter for experiment. In very wet impervious soils we have sometimes placed drains only 12½ feet apart. This was in low *poyal* land where the outlet was only 2½ feet lower than the surface of the field. In more favorable circumstances drains 100 feet apart and 3½ to 4½ below the surface have been satisfactory. Not infrequently the depth and spacing vary considerably in the same field, owing to the difference in soil and in the amount of water to be removed.

It has been our practice to cover tile, which has been laid to grade, with from four to six inches of graval, to prevent entrance

of silt and facilitate entrance of water. In very soft soil we have used a trough of one-inch lumber under the tile to preserve grade and prevent broken alignment of tiles.

The use of the tile drains instead of open ditches has several, advantages. Tile drains once placed do not have to be cleaned as do open ditches. In only two or three instances have drains become clogged in our three-year experience, and it is believed that the useful life of the average drain will be at least ten years, probably much more.

The use of tile drains permits plowing and cultivation by animal power which is not possible when frequent open ditches are encountered.

The covered drains permit all of the surface to be used for planting. In some cases 25 per cent more cane can be planted in the same field.

With covered drains the cutting and hauling of the cane is facilitated and none of the cane is lost by falling into open ditches.

RESULTS

The object of a well-designed system of drainage is to lower the ground water level, thus permitting aeration of the soil and making available the plant food contained in that portion of the soil not previously reached by the feeding roots of the cane. This, in practice, makes available virgin soil to a depth in some cases of two or three feet. The effect is seen in the increased growth and production of the cane.

The first field drained by tile at Mercedita was planted to cane in September 1921, the wet part being plowed for the first time. Previous planting had been in holes made in the banks between ditches. The crop was harvested in 1923 with an average yield of 56 tons cane per acre. The previous record of this field was, 1917, 11 tons per acre; 1918, 27 tons per acre; 1919, 21 tons per acre; 1920, 28 tons per acre; and 1921, 27 tons per acre.

Another illustration of the possibilities of drainage was furnished by a field of low-lying land just east of Inabón River. This field was planted each year 1918–1919–1920 and nearly all the cane was killed by back water from the river each year.

In the summer of 1921 a dike was constructed to hold back the flood waters and a ditch made the inner side of the dike. Into this ditch drain tiles discharge the water from the filed, which is

only 4 to 5 feet above sea level. Owing to lack of fall for natural drainage the water is removed from the ditch by pumping it over the dike, about 4 feet lift. The result was a crop averaging 47 tons per acre on 20 acres of land that had given no crop from three previous plantings.

Similar instances can be multiplied from our own experiences and the work of installing tile drains in all fields that have required ditches is being pushed forward.

One of the inevitable consequences of irrigation is the formation of wet spots in many fields when the subsoil does not provide natural outlet for the surplus water applied. These wet spots after a few years become salty from the continued surface evaporation. Tile drainage offers a practicable means of remedying this condition and the earlier it is applied the better, since once the soil is thoroughly impregnated with salts it may take a number of years to remove the excess so that crops will grow again. Some of the earliest drains installed at Mercedita are still discharging saline water and part of the area drained will not produce cane, but these areas are growing smaller each year and we hope that within a few more years, the whole will be reclaimed.

An example of this condition is a field near Mercedita factory which has a salty spot near its center. This portion of the field was not planted for some years of failure to produce.

Tile drains were placed in the wet portion in the spring of 1921. The previous record of the field was:

1917_____	4 *cuerdas*	Gran Cultura	40 tons per *cuerda*
1919_____	7¼ *cuerdas*	Gran Cultura	37 tons per *cuerda*
1920_____	7¼ *cuerdas*	Primavera	24 tons per *cuerda*
1921_____	7¼ *cuerdas*	Rateons	13 tons per *cuerda*

After tiling the whole field 10 *cuerdas* were planted as but only 9¼ acres were harvested, which gave a crop of 23 tons per acre in 1923 as *gran cultura* altho about one-half acre had practically no cane on it. The average for the 10 acres was 37 tons. The non-productive portion is smaller and it is expected that in another year or two cane will be growing on the entire area.

MORPHOLOGICAL SIMILARITY BETWEEN THE PHYTHIUM-LIKE FUNGUS FOUND ASSOCIATED WITH DISEASED SUGAR-CANE ROOTS IN HAWAII AND PORTO RICO

By B. A. Bourne,
Professor Plant Pathology, College of Agriculture and Mechanic Arts

The first pathologist in more than two decades since 1896 to

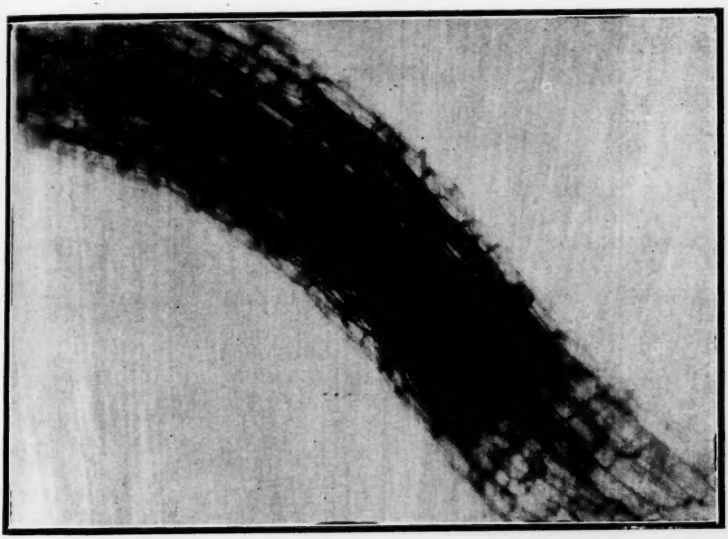


FIG. 1.—Photomicrography of secondary rootlet of sugar cane near root tip showing area of dark reddish-brown tissue found in cases of typical *Pythium* root-rot. X 165.

claim that a fungus having characters resembling the genus *Pythium* was a primary cause of that condition in sugar cane known as "root disease" was Mr. C. W. Carpenter (1) of the Hawaii Agricultural Experiment Station. In fact, the experiments he described with this fungus in 1919 leave little doubt that it is a vigorous parasite under certain conditions in Hawaii and can be made to reproduce the typical symptoms of root disease under carefully controlled experimental conditions.

Prof. Earle (3) has already pointed out that Dr. Treub in 1885 and Dr. Wakker in 1896 have both found *Phythium* associated with root disease in Java, but that the more conspicuous *Marasmius* seems to have attracted Dr. Wakker's attention as well as that of subsequent investigators and no further mention of the former fungus as being associated with a cane disease has been found in literature until that of Carpenter previously mentioned.

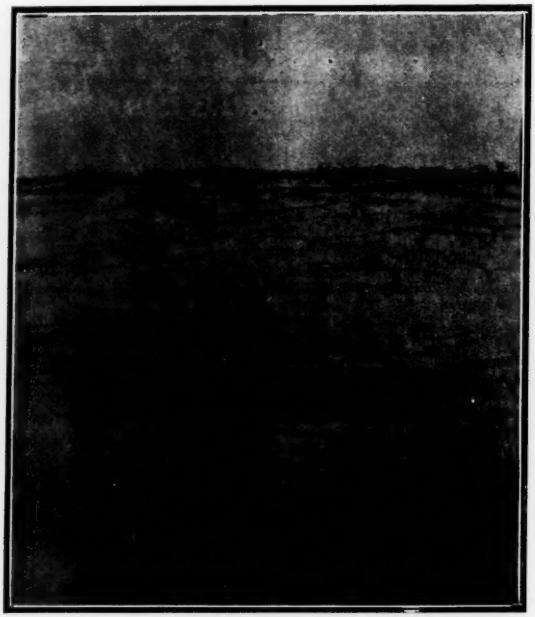


FIG. 2. — Photomicrograph of a longitudinal section through a reddish-brown diseased portion of a primary cane root affected with *Pythium* root-rot. Note the thick type of mycelium seen in one of the epidermal cells in the center of the picture. X 170.

Here in Porto Rico the first mention of *Pythium* as being isolated from roots of sugar cane suffering from root disease was recorded in 1920 by Mr. Matz (4) recently Pathologist of the Insular Experiment Station. Although Mr. Matz's experiments leave little doubt that *Pythium* is a vigorous parasite on cane roots under certain conditions and can be made to induce rot in these under experi-

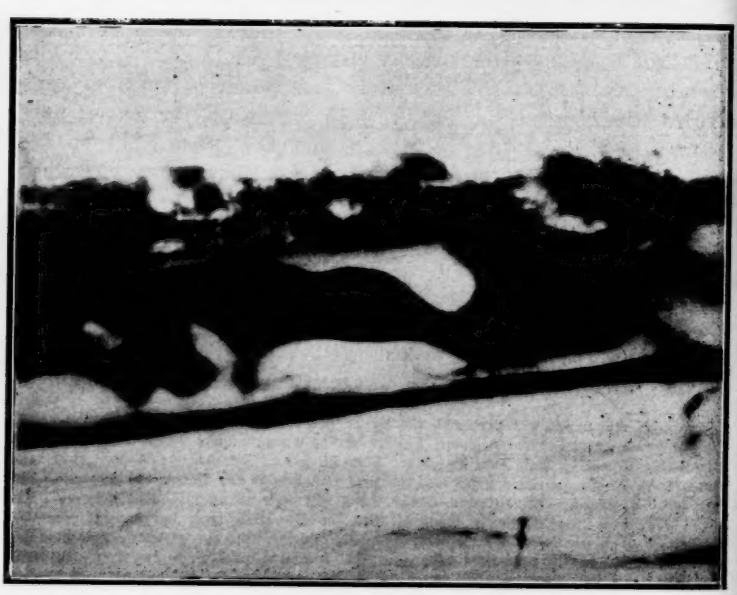
mental conditions just the same as was shown by Carpenter in Hawaii, yet it has not been satisfactorily demonstrated that the species present in Porto Rico can reproduce all the true symptoms of root disease, including marked stunting of the cane such as is claimed by Carpenter for the Hawaiian fungus. So far as is known, inoculation experiments with *Pythium* sp. under Porto Rican conditions have not yet been tried with the *Lahaina* variety (probably the same as the Bourbon, Otaheite and Caña Blanca) which is known to be particularly susceptible and which was used by Carpenter in his inoculation experiments.

In the abscence of definite evidence, therefore, as to whether we have here a different species of *Pythium* or a different biological strain of the same species as is found in Hawaii, it would seem desirable to present evidence relative to the morphological similarity between the two fungi as they exist naturally in cane roots and also in pure culture in the two countries. It is not the purpose of this paper to discuss the life history of the species of *Pythium* found here, since this would not clear the situation in the absence of similar studies with the Hawaiian parasite. So far no detailed description or figures of the *Pythium* found in Porto Rico have been published, and the writer believes that in presenting certain results recently obtained by a histological examination of roots of cane affected with this fungus, together with certain observations of pure cultures of the parasite, he will be throwing some light on the similarity between the organism found here and the one described from Hawaii.†

Figure 1 represents a typical secondary rootlet of cane[1] affected with *Pythium* root-rot. The dark reddish-brown area toward the central portion of the stele seems to be quite characteristic and is usually present a short distance back from the root tip, being often easily visible to the naked eye. This typical appearance is found also in tertiary roots. The exact reason why the fungus

† Since this paper was prepared, the writer has seen a copy of Mr. Carpenter's subsequent paper entitled *"Morphological Studies of the Pynthium-like Fungi Associated with Root-rot in Hawaii"*. Bul. Exp. Sta. Haw. Sug. Pl. Assoc. Bot. Ser. 3: 59–65. 1921, and also Dr. H. M. Fitzpatrick's paper on *"Generic Concepts in the Pythiaceae and Blastocladiaceae"*. Mycologia: *15 : 166–173*. 1923. Not only is it abundantly clear that the Porto Rican fungus is morphologically identical with the Hawaiian type, but according to Dr. Fitzpatrick it is really a *Nematosporangium*, the thicker type of globular, mycelium-like structure found in the epidermal cells (see figs. 3 and 4 present paper) being the true sporangium or asexual stage. The latter author has suggested the name *Nematosporangium aphanidermatum* (Edson) comb. nov. for this fungus.

[1] B. 6450 variety was the one studied throughout for the purpose of writing this paper.



FIGS. 3 AND 4.—Photomicrographs of longitudinal sections of epidermal cells of a primary root of sugar cane showing typical globular and *Pythium*-like fungus present therein. X 1,650.

reacts so peculiarly with the host tissue in the region of the young root where the distinct tissues of cortex and stele are beginning to become differentiated is as yet not clearly understood. Similar reddish-brown lesions are also to be found on tender primary roots, although these are scattered irregularly and may be quite large (over a centimeter in length) owing to the gradual extension of the fungus from the original point of entrance, and perhaps also to the coalescence of individual lesions.

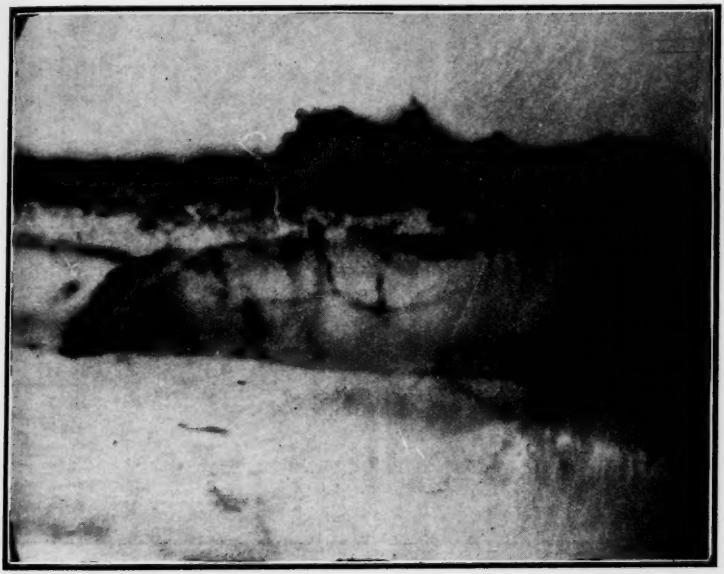


FIG. 5.—Photomicrograph of longitudinal section of epidermal cell of a primary root of sugar cane showing typical fine, cylindrical type of *Pythium*-like mycelium ramifying throughout the interior. X 1,650.

Figure 2 is a longitudinal section of a primary cane root showing one of the epidermal cells invaded with the thicker type of *Pythium*-like mycelium. It is interesting to note that this type of mycelium is seldom found any deeper than the first two layers of cells in the root and most commonly just in the epidermal layer as shown in figures 2, 3, and 4. Figures 3 and 4 show the typical globular and characteristically shaped mycelium of the *Pythium*-like fungus inhabiting the epidermal cells of an affected primary root. The writer

especially desires to draw attention to the great similarity between this mycelium and that figured by Carpenter in Hawaii. It is worth mentioning, moreover, that this thicker mycelium stains quite easily with safranin (1 per cent solution in 50 per cent ethyl alcohol) whereas the finer type seen ramifying in the epidermal cell shown in Figure 5 is so poorly stained with safranin that it could not be recognized except with the greatest difficulty. The iron-alum-

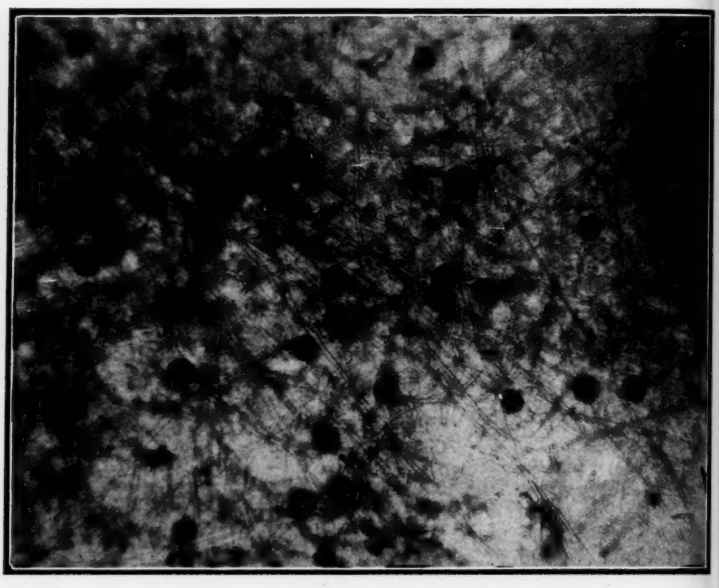


FIG. 6.—Photomicrograph of a living pure culture on corn meal of the *Pythium*-like fungus associated with cane root-rot. Note typical branching of mycelium and abundant production of oögonia. X 165.

haematoxylin cytological stain was found to be far superior for staining both types of the *Pythium*-like thallus. Carpenter also mentions and figures a similar type of fine cylindrical mycelium as shown in Figure 5 inhabiting an epidermal cell. This type of mycelium in addition to being found in epidermal cells has also been seen by the writer inhabiting root hairs, and in fact numerous stained sections show it to be present throughout the cortex and stele tissues as well as at the origin or secondary roots. As a whole this

type of thallus seems to predominate in the roots, but will easily escape recognition unless suitably stained as metioned above.

Carpenter (1) mentions that the *Pythium*-like fungus he obtained in Hawaii produced oöspores on rice cultures, while Earle (3) in Porto Rico states that oöspores were produced abundantly in Mr. Matz's cultures. Fig 6 shows how abundantly oögonia are found in young pure culture of the Pythium-like fungus on corn meal isolated by the writer. Fig. 7 shows some of these oögonia more highly

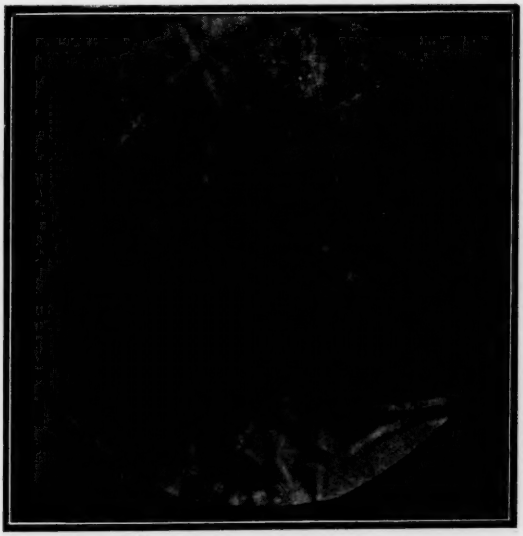


FIG. 7.—Photomicrograph of living culture of the *Pythium*-like fungus on corn meal. *x*, antheridium attached to wall of oögonium; *y*, oösphere or egg cell. X 943.

magnified and in addition one of them may be seen to have a typical antheridium ($\times$) firmly attached to its outer wall for the purpose of fertilizing the oösphere, or female egg cell (y) present within. Great similarity is here noted in the manner of fertilization of the oösphere as figured by Carpenter.

Fig. 8 shows the oöspores formed after fertilization. At this stage they have not yet been freed from the wall of the oögonium (a) and in addition to being invested with a thick inner wall (c), they also are surrounded by a relatively thicker layer of prei-

plasm (*b*) which is seen in the preparation to have taken the stain with difficulty. Anton De Bary (2) regards this periplasm layer in the case of the genus *Pythium* as an inconspicuous, sparingly granular mass of protoplasm surrounding the oöspore, but which cannot be seen to take part in the process of its maturation. It is possible that it may serve as a protective covering when the oöspore is liberated, or it may soon be dissolved away.

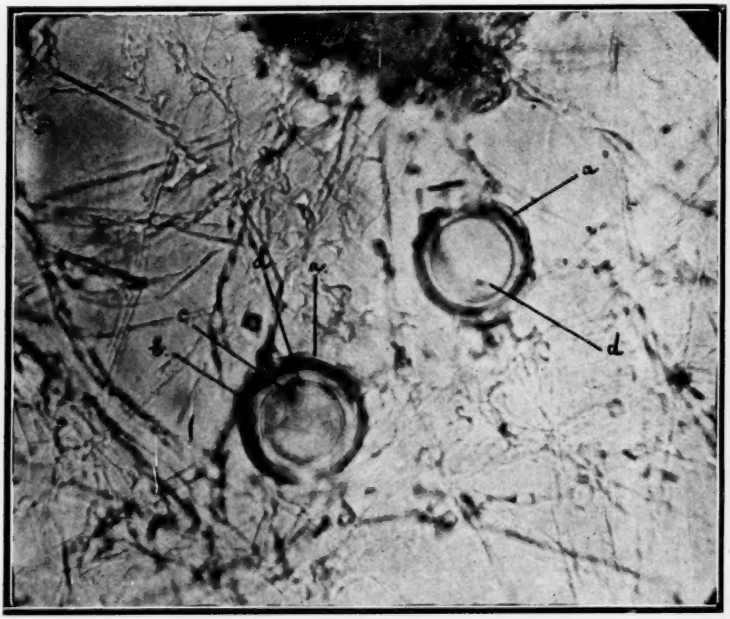


FIG. 8.—Photomicrograph of stained preparation of *Pythium*-like culture showing two mature oöspores. *a*, wall of oöganium; *d*, periplasm layer; *c*, inner wall of oöspore; *d*, probably the nucleus of the oöspore. X 1,073.

As far as comparison of the fungi from the two countries is concerned, relative to the size of mature oöpores as well as oögonia at the time of fertilization, this is hardly possible at present since the average sizes of these structures calculated from a large number have not apparently been worked out for the Hawaiian organism. Furthermore, the writer has not grown his organism on rice cultures as used by Carpenter, but on sterile corn meal as well as dextrose potato agar, so that it is feared that this difference in medium would

be a serious objection if accurate comparison in the size of these organs was undertaken. However, the similarity in size is indicated by making use of the figures of definite magnification given for the Hawaiian organism.

A typical oöspore figured by Carpenter on Plate 8, Fig. F. shows the inner granular oöspore, without the periplasm and oögonium wall, to be 15 microns in diameter. Both oöspores figured by the writer in Fig. 8 have a diameter of 12.12 microns without the periplasm and oögonium wall. Thus there is only a difference of about three microns, a variation easily possible in the same strain on different media.

SUMMARY

1. Histological investigation of roots of B. 6450 variety of cane in Porto Rico suffering from *Pithium* root-rot has demonstrated thas this fungus as it exists in the tissues, bears a remarkable morphological similarity to the *Pythium*-like organism figured by Carpenter from Hawaii in the roots of the Lahaina variety.

2. Iron-alum-haematorylin cytological stain has been found very suitable for staining both the thick and globular as well as the fine cylindrical types of *Pythium*-like thallus in cane roots. The latter type of mycelium was found to be by far the most common in the root tissues examined, the former kind being confined mainly to the outer one or two layers of cells.

3. Pure cultures of the *Pythium*-like fungus on sterile corn meal produce abundant oögonia having oöspheres which are apparently fertilized in a similar manner to the Hawaiian organism.

4. Such comparison as has been possible shows that mature oöspores of the organism from the two countries are so similar in size as to possibly come within the range of ordinary variation within the species.

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